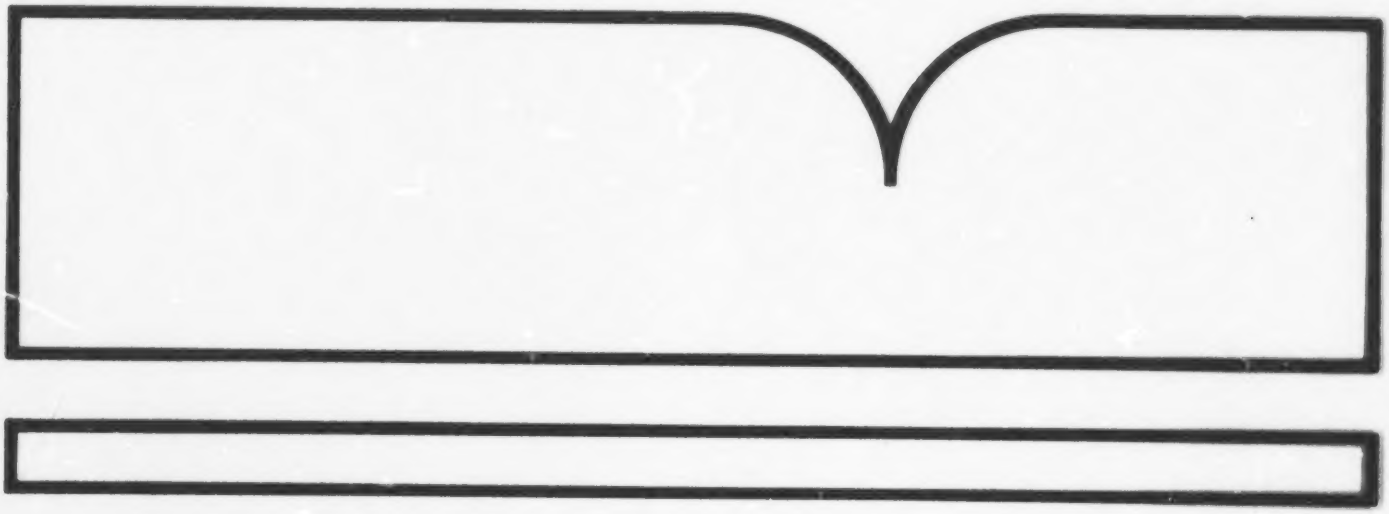
PB86-143872

Tech 4 Credit Model: Estimates for Emission Factors and Inspection and Maintenance Credits for 1981 and Later Vehicles for MOBILE3

(U.S.) Environmental Protection Agency
Ann Arbor, MI

Oct 85



U.S. Department of Commerce
National Technical Information Service
NTIS

PB86-143872

EPA-AA-IMG-85-6

Technical Report

Tech IV Credit Model:

Estimates for Emission Factors and Inspection and Maintenance Credits for 1981 and Later Vehicles for MOBILE3

by

David J. Brzezinski

October 1985

NOTICE

Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

Technical Support Staff
Emission Control Technology Division
Office of Mobile Sources
Office of Air and Radiation
U. S. Environmental Protection Agency

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-AA-IMG-85-6		PB86 143872/AS

4. TITLE AND SUBTITLE	5. REPORT DATE
Estimates for Emission Factors and Inspection and Maintenance Credits for 1981 and Later Vehicles for MOBILE3.	October 1985
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
David J. Brzezinski	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
U.S. Environmental Protection Agency Office of Mobile Sources Technical Support Staff Ann Arbor, MI 48105	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED Technical
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report provides the basis for the equations used in MOBILE3 to predict the emission levels of 1981 and newer gasoline powered light-duty passenger vehicles. This was done by characterizing the performance of vehicles in the Emission Factor data base separately for several technology types, such as fuel-injected versus carbureted, and recombining the technologies based on projected mixes to produce estimates of emissions of future model years. The Tech IV Credit Model is the computer software developed to calculate the MOBILE3 emission factor estimates. In addition, the model was used to estimate the emission reductions due to Inspection and Maintenance (I/M) programs for these vehicles. The emission levels of vehicles in the sample identified by various test type and cutpoint combinations were reduced to reflect repairs due to the I/M program. After combining the repaired and unrepaired vehicle emission levels, the overall reduction from the non-I/M base case is expressed as a fraction of the base case. This reduction fraction is scored in MOBILE3 and used to estimate fleetwide reductions due to I/M porgrams.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution	Nitrogen Oxides	Mobile Source Emissions model	
Exhaust Emissions	Regulations	Emission Factors	
Computer Programming	Motor Vehicles	MOBILE3 Computer Program	
Manuals	Fortran		
Mathematical Models	Computer Programs		
Hydrocarbons			
Carbon Monoxide			

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release Unlimited	unclassified	27
	20. SECURITY CLASS *(This page)* unclassified	22. PRICE

EPA Form 2220-1 (9-73)

Table of Contents

1.0 Background

2.0 Overview of Method

3.0 Vehicle Sample

- 3.1 Estimates for Normal Emitters
- 3.2 Estimates for High Emitters
- 3.3 Estimates for Super Emitters
- 3.4 Combined Deterioration Equations

4.0 Inspection and Maintenance Benefits

- 4.1 Short Test Data
- 4.2 I/M Short Test Errors of Commission and Omission
- 4.3 I/M Short Test Identification Rates
- 4.4 Effects of I/M

5.0 The Tech IV Credit Model

References

Figures

Tables

Appendix

1.0 BACKGROUND

The Tech IV Credit Model is used to estimate the emission factor equations and the effects of Inspection and Maintenance (I/M) programs for 1981 and later passenger cars (Tech IV) stored in the EPA MOBILE3 emission factor model. MOBILE3 is used to estimate future fleetwide emission levels of highway mobile sources.

There were two primary reasons for the development of the Tech IV Credit Model. First, the nature of the technology used to control emissions from 1981 and later passenger cars produce the random occurrence of vehicles whose emissions are many times the average emissions of the sample would not be properly accounted for using a simple regression through the existing data as is done to predict emission levels for all pre-1981 model year passenger cars in MOBILE3. Secondly, there was a need to estimate the impact of I/M programs on the emission levels of these vehicles for MOBILE3.

MOBILE2, EPA's previous model, also used a modeling process to estimate the Tech IV emission factors[1]*. This was necessary primarily because of the lack of data from vehicles which resembled the technology types expected to be commonly used in future years at the time MOBILE2 was completed. The MOBILE3 version of the Tech IV Credit Model makes use of the existing data sample of 1166 1981 and later vehicles. Each technology type is examined separately. The results are then combined into a final model year specific emission factor used in MOBILE3.

The emission factors for high-altitude areas used in MOBILE3 were also computed using a model similar to the model discussed in this report. A complete documentation of the differences between that model and this will be addressed in a separate report.

---

*Numbers in brackets refer to references listed at the end of the report.

2.0 OVERVIEW OF METHOD

The technology used to meet the more stringent emission standards beginning with the 1981 model year is continuing to change. While many manufacturers have utilized computer controls since 1981, others did not adopt them product-wide until more recently, especially in response to the 1984 all-altitude requirement. Also, more and more manufacturers are moving toward fuel injection. An EPA contractor has estimated the changes in technology over time into the future based on discussions with the major vehicle manufacturers [2]. Based on these forecasts it was felt that the Tech IV Credit Model should predict the emission levels of each distinct technology separately and then combine the results based on the fraction of the vehicle fleet predicted to use each technology in each model year group. In addition, vehicles receiving the CO waiver in 1981 or 1982 would be treated separately from non-waiver vehicles and the results of these two groups would be weighted together in those model years when waivers were issued.

The MOBILE2 version of the Tech IV Credit Model divided the sample into two emission level categories. This concept was retained and expanded in the MOBILE3 version. The most obvious division was between the majority of the vehicles and the outliers. Four vehicles with extremely high hydrocarbon (HC) and carbon monoxide (CO) emissions were identified in the sample [3]. These four vehicles are therefore treated separately. There remained many vehicles with high HC and CO emission levels which could not be statistically identified as outliers, but whose emission levels would likely be affected by an I/M program. As a result, the remaining sample was divided into two groups representing vehicles with generally acceptable emissions and those vehicles with higher than normal emission levels. Further sections of this report will discuss these divisions in more detail.

The general approach of the Tech IV Credit Model is to obtain statistical information about the emission levels of each division by emission standard and technology and to predict the emission levels of that division at any specified age measured by mileage. All divisions are then weighted together based on the predicted size of each division for each model year group.

The resultant emission level predictions when plotted versus mileage are nearly linear. For simplicity, MOBILE3 uses a linear input for the emission factor equation. Therefore, a linear equation is fit to the emission levels versus mileage for each model year group using a weighted regression. The weighting is determined by the vehicle mileage contribution of each age to the vehicle lifetime mileage accumulation. Further sections in this report will discuss each of these processes in more detail.

As described in the following pages, the method just described was repeated for the overall FTP (Federal Test Procedure) emission results and for each of the three "bags" of the FTP separately. The separate bag results are needed in MOBILE3 to correctly adjust for varying percentages of operation in the modes represented by the three bags.

In order to estimate I/M credits for these vehicles it was assumed that the emission levels of vehicles after repair would, on average, resemble the emissions of the division of the sample with acceptable emissions. Since not all vehicles with acceptable emission levels would pass their applicable EPA certification standards, this does not assume that all repaired vehicles will pass certification standards after repair. The estimation of the emissions of the fleet for the I/M case, therefore, resembles the process for estimating the non-I/M emissions except that some portion of the fraction of vehicles normally assumed to be outliers or in need of maintenance would instead be attributed to the category of vehicles with acceptable emission levels.

Once all of the categories had been weighted together, the non-I/M case and I/M program case for each age are compared and the reduction in emissions expressed as a percent. This percent reduction in exhaust emissions is stored in MOBILE3 and used to estimate the reduction in the emission factors due to I/M. I/M credits were calculated and stored only for the overall FTP, not for individual bags. Further sections in this report will discuss this process in more detail.

3.0 VEHICLE SAMPLE

On April 19, 1984, the Emission Factor Program (EF) data base included 1380 light-duty gasoline vehicles (LDGV) that had been built and certified to the current Federal NOx-standard of 1.0 grams per mile (gm/mi). This data set is updated relative to the data presented at the February 14, 1984 MOBILE3 workshop. It includes an additional 222 data records from further testing as part of the 1984 Emission Factor Program. The data include 137 1980 model year California cars certified to the 0.41/9.0/1.0 gm/mi (HC, CO and NOx) standard. These cars although representative of the advanced catalyst technologies under consideration are also the first cars made according to the tighter NOx emission standard. These vehicles may represent more of a prototype technology unrepresentative of current trends. They were too numerous to ignore, but too suspect to include without question. Therefore, they were included where their numbers were needed most, in the estimates of the deterioration slopes, but nowhere else.

Also included in the data were five vehicles which were certified to the California standards which did not require the use of a catalyst. These vehicles do not represent any technology expected to be used in the 1981 and later model year fleet. These vehicles were therefore not used in the model. Seven vehicles were certified to a 2.0 gm/mi NOx standard. These vehicles were granted waivers which were still available to certain manufacturers. These vehicles were left in the analysis to account for waiver vehicles. One California vehicle with a problem in the computer control module was excluded from the analysis because the manufacturer claimed to have eliminated the potential for this problem through a design change.

Visibly tampered vehicles were excluded from the analysis. The Emission Factor Program vehicles were examined for emissions system tampering. Not all forms of tampering yield significant exhaust emissions increases. Tampering of the air pump system, catalyst removal, misfueling of catalyst equipped cars with leaded gasoline and EGR system disablements were considered reasons for removal from the data. There were 87 vehicles (6%) identified with such tampering in the EF program passenger car sample. All 87 tampered cars were removed from the sample used in the analysis. MOBILE3 adjusts the emission levels predicted by the Tech IV Credit Model to reflect the emission impact of tampering separately.

The total non-tampered LDGV analysis data base includes 1292 records. Of these, 126 are 1980 model year California certified cars. The California cars were only used in the estimate of the deterioration slopes. The vehicles used in the analysis are described by model year, technology and emissions standards in Table 1 and Table 2.

In general, the randomized EF selection procedures tend to minimize data clumping by technology, manufacturer and mileage,* but there is a probable correlation between model year and mileage. As a result, the emission level prediction for deterioration versus mileage assumes that newer model year vehicles will obtain similar emission levels as older model year vehicles when they reach similar mileage levels. All of the outliers observed in the sample were 1981 model year cars.

Another apparent trend, the decreases in emissions in succeeding years, is due in part to the decreasing mean mileage associated with successive model years. The significance of these trends is limited by the lack of 1982 and later model year vehicles in the critical 3.4 gm/mi CO standard case, a factor that becomes even more important when the data are further divided into appropriate catalyst technology categories.

For purposes of the model, all vehicles in the sample which were not judged outliers were divided into two groups. The first group represents vehicles with accept ble emission levels. The second group represents vehicles with higher emission levels. The first group of "normal emitting" vehicles will subsequently be referred to in this report simply as "Normals". All non-outlier vehicles in the sample not judged to be Normals will be referred to as "Highs". The outliers themselves will be referred to as "Supers". Each of these emission level groups will be discussed in more detail in the following sections.

3.1 Estimates for Normal Emitters

One of the major reasons for dividing the sample into Normals and Highs is to assist in the modeling of I/M programs. In the model, any vehicle in the sample whose FTP emissions are greater than 1.5 gm/mi HC or 20 gm/mi CO is considered a High emitter. This level best divides the sample into Normals which tend to pass short tests and Highs which tend to fail short tests.

There are a total of 1219 Normal emitters among the non-tampered LDGV sample. The emission levels of the Normals are described in Table 1. They are distributed by technology and model year standards as shown in Table 2. On the basis of preliminary analyses, these normal emitters were divided into three principal related technology groups: closed loop (CLLP), open loop (OPLP), and oxidation catalyst only (Oxid). Then,

*Some specially recruited high mileage cars tend to introduce a bi-modality with respect to mileage.

bag-by-bag and combined-FTP deterioration factors (slopes) were determined for each by means of linear regression with respect to mileage using dummy variables specific to technology, model year and the CO emission standard. This procedure determines a best fit slope for each combination of technologies, minimizing the effects of coincidental technology, model year and emission standard correlations with mileage. All of the data, including the 1980 model year California data, were used in these regressions. The resulting deterioration factors are listed in Table 3.

Normal emitter zero-mile intercepts were calculated for the various technology and model year-emission standard subcases using the subcase mean emissions, E_n, and mean mileages, M, and the appropriate deterioration factors (DF_n)as follows,

$$ZM_n = E_n - DF_n * M.$$

The 1980 model year California certified cars were excluded from the calculation of zero-mile intercepts. This left 1105 normal emitting vehicles upon which to base the estimates of the zero-mile intercepts shown in Table 4.

Since there are no outliers with regards to oxides of nitrogen (NOx) emissions and since I/M programs are not assumed to result in repairs that significantly affect NOx, all vehicles in the sample are considered Normal emitters with regards to NOx emissions. The NOx emission zero mile intercepts for Normals therefore are based on the total non-tampered sample of 1166 vehicles. Also, the following discussions of Highs and Supers, therefore, do not apply to NOx emissions.

3.2 Estimates for High Emitters

High emitters are defined here as those light-duty vehicles that either have FTP-HC emissions greater than 1.5 gm/mi or have FTP-CO emissions greater than 20 gm/mi and which are not outliers. These vehicles tend to fail the I/M short tests. They are not otherwise special and other choices for FTP cutoff levels have been shown to yield essentially equal estimates of emissions deterioration when used in the model. The particular cutpoints used were chosen such that the majority of all vehicles failing the I/M short tests would be considered High emitting vehicles for purposes of the model. There is no comparable group for NOx since all vehicles are considered Normal emitters for NOx emissions.

The proportion of High-emitters observed in the sample is not uniform but rather increases with increasing mileage. Overall, the data would be fit by the following linear regression:

$$W_h = -0.00973 + 0.027597 * M$$

The equation becomes positive at 3,500 miles, a small offset from the origin which is not significant. The equation equals 0.128 (12.8%) at 50,000 and 0.266 (26.6%) at 100,000 miles. As explained below, this single overall linear fit was not used in the model.

The 57 High emitters are distributed by technology, model year and emission standard as shown in Table 2. They are not equally distributed by technology, and therefore, separate estimates of W_h for the High-Emitters have been made for closed-loop carbureted (CLLP/Carb), closed-loop fuel injected (CLLP/FI), open-loop 3-way catalyst (OPLP) and pure oxidation catalyst (Oxid) cars.

The closed-loop fuel-injection category of cars is especially important because it is projected to dominate sales by 1986. However, there were only 122 of them in the sample at the time of this analysis. Therefore for purposes of determining the emission levels and other characteristics of CLLP/FI Highs, this category has been augmented by including as CLLP/FI equivalents, any CLLP/Carb (Normal or High) whose emission failure was not due to carburetor problems.

We have assumed for purposes of the model that the proportion of High emitters will increase in a piece-wise linear fashion from the origin. There is reason to suspect that beyond 50,000 miles, the "useful" life of passenger cars for certification purposes, that the rate of increase in the number of High emitters will increase. This increase would be due to loss of warranty coverage and general poor maintenance given to used cars by owners. Therefore, the model assumes that beyond 50,000 miles the rate of increase of the Highs will double.

The model uses a two-stage equation to predict the proportion of vehicles in a fleet which will have high emissions. The equation expresses the proportion as a linear function of the average odometer mileage of the vehicles. It has two segments to accomodate the assumed change in the rate of increase of the occurrence of High emitters as the vehicles age. The following assumptions are used.

-There are no High emitters at zero miles, but vehicles start to become High emitters as soon as they are driven.

-The boundary, or "kink", between the segments should occur at 50,000 miles. This assumption is based on the common definition of the "useful life" of a vehicle.

-The slope of the segment which follows the kink is twice that of the first segment. This assumption reflects the increased wear and possibly less diligent maintenance of older vehicles, which would cause than to become High emitters at an increased rate.

With these assumptions in place, the function is as follows:

$$f(x) = \alpha x \qquad (x \leq 5)$$

$$f(x) = 2\alpha x - 5 \qquad (x > 5)$$

where:

- $f(x)$ is the proportion of high emitters in the fleet at mileage level, x.
- x is the odometer mileage (x 10k miles).
- α is the slope of the first segment.

Note that only one value, α, is needed to complete the function. The least-squares method was used to find a value of α which allows the function to best describe the behavior of each technology subset in the sample. The method was applied as follows:

- E is the error term, in this case it is a function of α.
- i denotes an individual vehicle in the set.
- Y is a variable which indicates the emission category of vehicle i. Y = 1 if emissions are "high", 0 if emissions are normal.
- b denotes the group of vehicles with mileages less than or equal to 50,000 ($x \leq 5$).
- c denotes the group of vehicles with mileages greater than 50,000 ($x > 5$).

The equation for the error would be as follows:

$$E^2 = \sum (f(x_i) - Y_i)^2$$

$$= \sum_b (\alpha x_i - Y_i)^2 + \sum_c (2\alpha x_i - 5\alpha - Y_i)^2$$

To find the value of α where E^2 (and, thus, the error E) is minimized, the value which causes the derivative, $dE^2/d\alpha$, to be zero must be found.

$$dE^2/d\alpha = \sum_b 2(\alpha x_i - Y_i)x_i + \sum_c 2(2\alpha x_i - 5\alpha - Y_i)(2x_i - 5)$$

$$= \alpha\sum_b x^2 - \sum_b Y_i x_i + \alpha\sum_c (2x_i - 5)^2 - \sum_c Y_i(2x_i - 5)$$

$$= 0$$

Then, solving for the slope α,

$$\alpha = \frac{\sum_b Y_i x_i + \sum_c Y_i(2x_i - 5)}{\sum_b x^2 + \sum_c (2x_i - 5)^2}$$

The slope of the equation, α, was then determined for each technology subset of the sample. The resultant 0 to 50,000 mile slopes are listed below.

$W_h = 0.0250 * M$	for CLLP/Carb
$= 0.0193 * M$	for CLLP/FI
$= 0.0401 * M$	for OPLP/Carb
$= 0.0$	for Oxid

The High emitter emission level magnitudes (ZM_h) are the bag-by-bag High emitter emission means for each of the four technology categories. These emission levels are not assumed to increase with increasing age. The number of vehicles in this emission category is assumed to increase with age as described above. The High emitter magnitudes are listed in Table 5.

The estimates for High emitter emission levels do not include the 1980 model year California certified vehicles.

3.3 Estimates for Super Emitters

There were four outliers identified in the sample.[3] All of these Super emitters were closed-loop carbureted vehicles. Two of these vehicles had emission problems which might also occur on closed-loop fuel-injected vehicles and therefore were used to simulate the emission levels of fuel-injected Super emitters.

Since only four Super emitters were observed in a total closed-loop carbureted and fuel-injected vehicle sample, the following equation best describes the occurrence of Super emitters.

$$\text{Number of Supers} = W_{s,c} * M_c * N_c + W_{s,f} * M_f * N_f = 4$$

Where:

$W_{s,c}$ = Rate of carbureted Supers
$W_{s,f}$ = Rate of fuel-injected Supers
M_c = Mean mileage of carbureted vehicles
M_f = Mean mileage of fuel-injected vehicles
N_c = Number of carbureted vehicles
N_f = Number of fuel-injected vehicles

And for this sample:

M_c = 22,092 miles
M_f = 18,293 miles
N_c = 656 vehicles
N_f = 122 vehicles

Although all four observed Super emitters were carbureted vehicles, the sample of fuel-injected vehicles is small enough so that it is not surprising that no fuel-injected Supers were observed. Further, since only two of the four malfunctions observed in the Supers could have occurred on fuel-injected vehicles, the observed rate of Supers among fuel-injected vehicles would be expected to be less than for carbureted vehicles. It was assumed that the rate of occurrence of Supers for fuel-injected vehicles is half the rate for carbureted vehicles.

$$2 * W_{s,f} = W_{s,c}$$

If we then solve the previous equation for the rate of occurrence of fuel-injected Super emitters, we get the following equation.

$$W_{s,f} = 4 \; / \; (\; 2 * N_c * M_c + N_f * M_f \;)$$
$$W_{s,f} = 4 \; / \; (\; 2 * 656 * 2.2092 + 122 * 1.8293 \;)$$
$$W_{s,f} = 0.0012814 \text{ / } 10{,}000 \text{ miles}$$
$$W_{s,c} = 2 * W_{s,f} = 0.0025628 \text{ / } 10{,}000 \text{ miles}$$

The rate of occurrence of Supers is assumed to increase linearly with mileage starting at the origin. Unlike the High emitters, the rate of increase is not assumed to change beyond 50,000 miles.

The Super emitter emission level magnitudes (ZM_s) are the bag-by-bag Super emitter emission means for each of the technology categories. As with the High emitters, the emission levels of the Super emitters are assumed not to increase with age. The Super emitter emission level magnitudes are listed in Table 5.

3.4 Combined Deterioration Equations

As indicated previously, the estimates of the rate at which vehicle emissions increase is a weighted sum of the separate emission contributions of Normal, High and Super emitters,

$$E = (1-W_h-W_s)(ZM_n+DF_n*M) + W_hZM_h + W_sZM_s.$$

As an illustration, the combined FTP-CO emissions of 1981 and later, 3.4 gm/mi CO-standard, closed-loop carbureted, 3-way catalyst with oxidation catalyst (CLLP/OX3W/Carb), non-tampered, light-duty vehicles are calculated to be:

$$CO = (1 - .0250M - .002563M)(1.948 + .6459M)$$

$$+ .0250(39.137)M + .002563 (193.23)M$$

$$CO = 1.948 + 2.0666M - 0.0178M^2 \text{ (gm/mi)}$$

This equals 7.00 gm/mi at 25,000 miles and 11.83 gm/mi at 50,000 miles. In the model the rate at which High emitters occur doubles at 50,000 miles. Beyond 50,000 miles, W_h becomes 0.0499*M for this case and the FTP CO emission equation becomes:

$$CO = -2.3403 + 3.0046M - 0.003389M^2 \text{ (gm/mi)}$$

FTP CO then equals 11.83 gm/mi at 50,000 miles, 18.28 gm/mi at 75,000 miles, and 24.31 gm/mi at 100,000 miles.

A set of emission levels are calculated for each technology in each model year using the appropriate quadratic equations for each mileage corresponding to the model year anniversary. These emission levels combine the emission levels of the Normal, High and Super emitters in each technology group. The emission levels of the technology groups are then weighted together at each anniversary mileage by the fraction of the model year equipped with each technology. These technology projections are described in Table 6.

The combined emission levels at each model year anniversary define the predicted emission levels of the model. For MOBILE3, a linear Least Square Regression is then fit to the predicted emission levels, weighted by the vehicle mileage contribution of each model year anniversary to the vehicle lifetime mileage accumulation.

Figure 1 shows an example of a linear fit to the predicted emission levels. This best linear fit is the equation used by MOBILE3 to predict non-tampered emission levels.

4.0 INSPECTION AND MAINTENANCE BENEFITS

Inspection and Maintenance (I/M) short tests of vehicle exhaust emission concentrations are simple tests that can be performed cheaply and in a minimum amount of time. These tests include an idle test and a two-speed test either unloaded or loaded using a dynamometer. The I/M short tests are much more likely to fail Super and High emitters than they are to fail Normal emitting vehicles. This fact is used in I/M programs to identify vehicles which most need maintenance and most contribute to the emissions of the fleet in excess of certification standards.

As in MOBILE2, MOBILE3 uses a modeling approach to estimate the impact of I/M on vehicle emissions [4]. Actual in-use data of the effects on emission levels of typical repairs as a result of an operating I/M program were not available at the time MOBILE3 was released. As a result, many of the assumptions used in the model are based on experience with vehicle owner behavior in I/M programs and laboratory repairs of 1981 and later model year LDGVs. When new information is collected, the assumptions can be substituted by observed effects. For now, the model represents EPA's best estimate of the effects of I/M on the emissions of 1981 and later model year LDGVs.

The remainder of this section deals with the application of three typical I/M short tests to the EF non-tampered LDGV sample. The three tests are:

1) Idle Test
2) 2500/Idle Test
3) Loaded/Idle Test

4.1 Short Test Data

The Emission Factor Program (EF) sample used for determination of I/M program credits contains 1166 non-tampered light duty vehicles (LDGV). The data exclude the California certified vehicles. Of these, 668 (57%) had measured FTP HC and FTP CO emissions less than or equal to those at which they were certified (0.41 gm/mi for HC and 3.4 or 7.0 gm/mi, for CO) and 498 (43%) exceeded their certification standards for either HC or CO emissions. The FTP HC and CO emission and mileage means for the Normal, High and Super emitters among these FTP passes and FTP failures are listed in the following table.

FTP HC and CO Emission and Mileage Means:
FTP passes versus FTP failures

	FTP Passes	FTP Failures		
	Normals	Normals	Highs	Supers
Sample Size	668	437	57	4
HC (gm/mi)	0.260	0.551	2.256	14.132
CO (gm/mi)	2.851	6.713	37.087	193.23
Mileage(10K)	1.4662	3.1048	4.8110	2.8157

The Idle Test tailpipe emission levels were gathered mainly from the second idle in neutral of the four-mode test procedure. In this procedure the vehicle is tested at curb idle, with the idle speed held at 2500 rpm, at curb idle again, and finally at curb idle with the vehicle transmission in drive with the brake on for vehicles with automatic transmissions. The second idle measured in this procedure best simulates a preconditioned idle test procedure.

The 2500/Idle Test data for this analysis were derived mainly from the same four-mode test procedure. In this case the emissions sampled at 2500 rpm and from the second idle in neutral are used. Vehicles must pass both the 2500 rpm mode and the idle mode of this test.

The Loaded/Idle Test data for this analysis were derived from the loaded two-mode test procedure. Vehicles must pass both the loaded high speed mode at 30 mph and idle mode in neutral.

Restart test procedure results were substituted for the above four-mode test data for all vehicles manufactured by the Ford Motor Company in the sample with restart procedure results. In addition, there were 22 vehicles in the sample for which neither four-mode test, restart test nor loaded two-mode test data were available and for these cars the idle emission readings taken during the engine parameter check were substituted.

4.2 I/M Short Test Errors of Commission and Omission

Errors of commission are vehicles which fail an I/M short test but which do not exceed their certification standards for HC or CO emissions. Errors of Omission are vehicles which pass the I/M short test but which exceed their certification standards either for HC or CO emissions or both.

I/M short test results for vehicles that had passed or failed their FTP criteria were examined to determine the errors of commission and omission, E_c and E_o.

Table 7 lists the numbers of true failures and passes and the number of false failures (errors of commission) and passes (errors of omission) for each of the three I/M short tests and for the three sets of test stringency criteria (CO and HC cutpoints) used in the model.

The number of correctly identified FTP failures increases with increasing test stringency. About twice as many FTP failures fail the 0.5%/100ppm (CO concentration/HC concentration) test criteria as fail the 3.0%/300ppm cutpoints. Similarly, the Loaded/Idle Test identifies more FTP failures than the 2500/Idle Test which in turn identifies more FTP failures than the basic Idle Test.

For a typical test, the Idle Test with 1.2%/220ppm cutpoints, 57% of the cars are correctly passed and 3.1% are correctly failed. In addition, this test falsely passes 38% (errors of omission) and falsely fails about 0.2% (errors of commission) of these cars. This last category is of special interest. Both the 2500/Idle test and the Loaded/Idle Test have more errors of commission than the Idle Test does. The Loaded/Idle Test, however, except for the tightest cutpoints, has a lower error of commission rate than the 2500/Idle Test. Thus, the Loaded/Idle Test not only appears to be both more stringent, but more selective than the more easily used 2500/Idle Test.

4.3 I/M Short Test Identification Rates

The raw I/M failure rates are easily calculated for each of the various I/M short tests by simply dividing the number of failures by the sample size. The I/M short tests, however, tend to identify the highest emitters in each group. The model for the 1981 and newer vehicles, therefore, uses a measure of the total emissions of the vehicles identified by the short test to quantify the impact of I/M. The short test FTP emission identification rate (IDR) tends to be larger than the simple failure rate and can be different for HC and CO emissions. In the MOBILE2 version of the 1981 and newer model year model, the IDR was determined as a fraction of only emissions in excess of certification standards.

Table 8 is a listing for each I/M short test result (pass or fail) of the number of cars, HC and CO emission means, and effective identification rates by emission category. The effective identification rate is determined by computing the total emissions identified by a particular combination of short test type and short test cutpoint pair and dividing that amount by the total emissions observed in that emission category for the sample. The effective identification rates for HC and CO emission are listed in Table 9.

When the three tests are compared, the Loaded/Idle Test and the 2500/Idle Test effective identification rates are greater than those of the Idle Test in all cases. Among the three levels of test stringency, as might be expected, the 0.5%/100 ppm criteria are more effective, and the 3.0%/300ppm criteria are least effective.

4.4 Effects of I/M

The model assumes that when a High or Super emitting vehicle is repaired to pass the I/M short test, the emission levels of the repaired vehicles will, on average, resemble the emission levels of Normal emitting vehicles at the same mileage. As a result, the I/M process is modeled as reducing the number of High and Super emitters and thereby increasing the number of Normal emitting vehicles. For each test type and cutpoint combination I/M test scenario, the IDR rate represents the fraction of High and Super emitters which revert to Normal emitting levels. At each inspection point in the model year lifetime measured in mileage, the number of High and Super emitting vehicles is reduced by the appropriate IDR. The emission levels with the reduced number of Highs and Supers is then calculated and compared to the non-I/M case to determine the I/M benefits for that scenario as a fraction of the non-I/M case.

There are separate IDR's for HC and CO emissions, but the same IDR's are used for all technology types. After the initial I/M inspection, the IDR reduction is only applied to the increase in the number of High emitters since the last I/M inspection. The IDR for Super emitters is applied to the total number of Super emitters in each inspection cycle.

Since the model only reduces the increase in the number of High emitters since the last inspection, there is always a growing fraction of vehicles which I/M is assumed never to detect. It is rationalized that if the particular emission problem which caused the vehicle to become a High emitter cannot be detected at the first I/M inspection, then it is reasonable to assume that the vehicle may never be detected by the I/M program by subsequent I/M inspections. An example of this type of problem would be a choke maladjustment, which might cause high overall emission levels, but might not be detected by a short test performed on a fully warmed engine. This assumption causes a portion of the High emitting vehicles to always remain High emitters and reduces the overall assumed effectiveness of I/M programs.

Between the inspection cycles the number of High and Super emitters is assumed to increase. However, the effects of I/M are assumed to have destabilized the normal rate of increase. Since the I/M repairs result in a larger number of Normal

emitting vehicles than would be expected in the absence of the I/M program, there is assumed to be a greater probability that Normal emitting vehicles will become High emitters proportional to the larger number of Normal emitters. The rate of increase in Super emitting vehicles is assumed to be unaffected.

$$\text{New Increase Rate} = \text{Basic Rate} * \frac{\text{Number of Normals After I/M}}{\text{Number of Normals Without I/M}}$$

The model assumes that I/M has no effect on the emission levels of Normal emitting vehicles. Some effect might be expected since some fraction of Normal emitting vehicles do fail the I/M short tests. In this model, however, no benefit is assumed from I/M repairs on Normal emitting vehicles.

The above process of adjusting the number of Normal, High, and Super vehicles is performed for each technology within a model year group and new emission levels for the model year group at its anniversary points. The I/M benefits are then computed for each model year group separately by comparison to the non-I/M case for that model year group. The model does not report the I/M benefits for each technology in each model year. The I/M benefits are computed from the predicted FTP emission levels before the levels are linearized.

5.0 THE TECH IV CREDIT MODEL

The Appendix contains a listing of the software used to model the emissions and I/M effects for 1981 and later model year passenger cars (LDGV). The listing is not the version which generated the I/M credits contained in the original release of MOBILE3. That version contained some coding errors which have been identified and corrected. The errors only affect the use of short tests other than the Idle Test using cutpoints other than 1.2% idle CO and 220 ppm idle HC. Alternate I/M credits for MOBILE3 reflecting these corrections are available from the Technical Support Staff in Ann Arbor [(313) 668-4367].

The Tech IV Credit Model was designed to evaluate programs which inspect vehicles once a year (annually). The model, however, has code which allows it to evaluate programs which inspect vehicles every other year (biennially). All of the assumptions described in this report apply to the biennial option. The only difference is the extended period of increase in the occurrence of High and Super emitters between inspections for the biennial case.

MOBILE3 uses the results of the Tech IV Credit Model to predict the reduction in the basic emission rates of 1981 and newer model year LDGV for I/M scenarios. In addition, MOBILE3 assumes that the presence of an I/M program will deter tampering of emission control devices and improper use of leaded fuel in catalyst vehicles. The resultant reduction in the fleet emission levels predicted by MOBILE3 for I/M programs combine the effects of the reduction in the basic emission levels directly attributable to the I/M repairs and the deterrence value of the program on tampering and misfueling. The effect of I/M programs on the basic emission levels for pre-1981 model year LDGV in MOBILE2 is described in another report [5]. The assumptions used for pre-1981 vehicles in MOBILE3 are nearly identical to those used in MOBILE2, having been updated only to reflect different mileage accrual rates.

References

1. EPA Inspection and Maintenance Staff, "Derivation of 1981 and Later Light-Duty Vehicle Emission Factors for Low-Altitude, Non-California Areas". EPA-AA-IMS/80-8, November 1980.

2. Energy and Environmental Analysis, Inc., Report of preliminary results of Work Assignment No. 35 Task 5, "Forecasts of Emission Control Technology 1983-1990", for EPA Contract No. 68-01-6558 to Phil Lorang dated November 28, 1983.

3. Ed LeBaron, EPA Technical Support Staff. Memo to Phil Lorang, EPA-TSS dated September 13, 1984.

4. Dave Hughes, EPA Inspection and Maintenance Staff, "Derivation of I/M Benefits for Post-1980 Light-Duty Vehicles for Low-Altitude, Non-California Areas". EPA-AA-IMS/81-2, Revised March 1981.

5. James Rutherford, EPA Inspection and Maintenance Staff, "Derivation of I/M Benefits for Pre-1981 Light Duty Vehicles for Low-Altitude, Non-California Areas". EPA-AA-IMS-82-3, June 1982.

Figure 1.

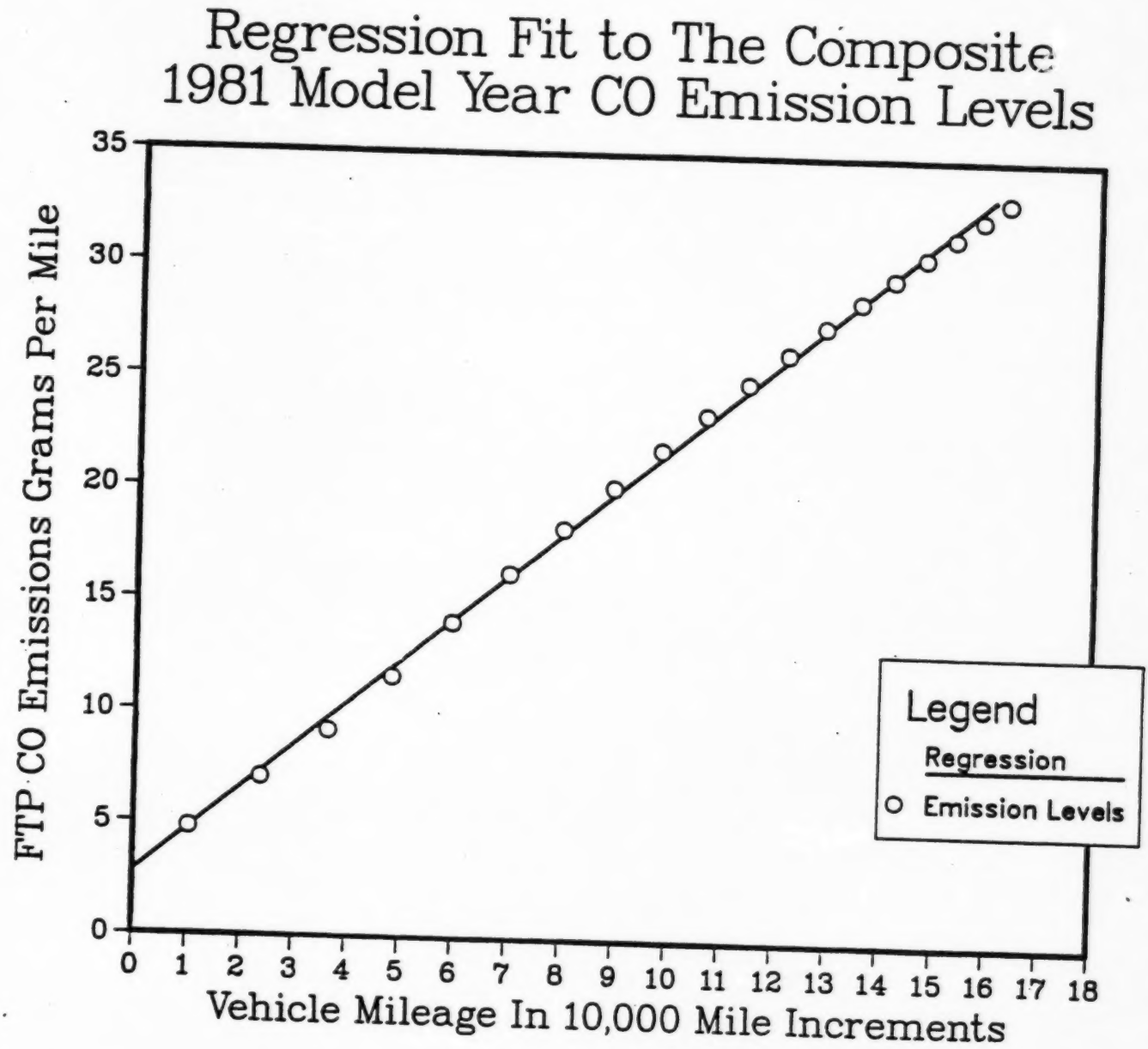

Regression Fit to The Composite
1981 Model Year CO Emission Levels
FTP CO Emissions Grams Per Mile
0
5
10
15
20
25
30
35
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Vehicle Mileage In 10,000 Mile Increments
Legend
Regression
Emission Levels

TABLE 1

FTP Emission and Mileage Means
by Model Year and Certification Standards

MYR-Stds(HC/CO/NOx)	Sample Size	HC (gm/mi)	CO (gm/mi)	NOx (gm/mi)	Mileage (10k-mi)
1981-.41/7.0/0.7					
Normals	196	0.319	3.94		1.0775
Highs	4	1.618	39.51		2.3644
All	200	0.345	4.65	0.584	1.1032
1981-.41/3.4/1.0					
Normals	372	0.375	3.68		2.7741
Highs	25	2.778	42.98		5.7758
Supers	3	15.327	172.69		2.7296
All	400	0.637	7.40	0.800	2.9614
1982-.41/3.4/1.0					
Normals	30	0.265	2.59	0.607	0.6965
1983-.41/3.4/1.0					
Normals	47	0.299	3.14		1.4653
Highs	1	2.080	8.89		3.5198
All	48	0.336	3.26	0.731	1.5081
1981-.41/7.0/1.0					
Normals	346	0.452	5.90		2.5986
Highs	27	1.873	32.31		4.3279
Supers	1	10.550	254.87		3.0738
All	374	0.582	8.47	0.845	2.7247
1982-.41/7.0/1.0					
Normals	107	0.295	3.77	0.698	0.8003
1981-.41/7.0/2.0					
Normals	6	0.327	4.13	1.360	2.9857
1982-.41/7.0/2.0					
Normals	1	0.320	3.30	1.800	0.6041
1980-.41/9.0/1.0					
Normals	114	0.346	4.95		1.7577
Highs	12	1.363	37.05		2.9421
All	126	0.443	8.00	0.831	1.8705
1980-1983 Myrs.					
Normals	1219	0.372	4.43		2.0809
Highs	69	2.101	37.08		4.4860
Supers	4	14.132	193.23		2.8157
All	1292	0.507	6.76	0.771	2.2116
1981-1983 Myrs.					
Normals	1105	0.375	4.38		2.1142
Highs	57	2.256	37.09		4.8110
Supers	4	14.132	193.23		2.8157
All	1166	0.514	6.63	0.764	2.2484

TABLE 2

Distribution of Non-Tampered Light-Duty Vehicles
by Technology, Model Year and Emission Standards

Model Year	1981	1982	1983	1981	1981	1981	1982	1982	1980	
HC Std.	.41	.41	.41	.41	.41	.41	.41	.41	.41	
CO Std.	3.4	3.4	3.4	7.0	7.0	7.0	7.0	7.0	9.0	
NO Std.	1.0	1.0	1.0	0.7	1.0	2.0	1.0	2.0	1.0	All
Normal-Emitters										
CLLP/OX3W/Carb	165	4	5	55	110	-	35	-	10	384
CLLP/ 3WC/Carb	34	3	-	63	126	5	9	1	48	289
CLLP/OX3W/FI	3	-	9	8	8	-	3	-	2	33
CLLP/ 3WC/FI	16	7	25	13	-	-	28	-	11	100
OPLP/OX3W/Carb	58	2	8	28	63	-	28	-	6	193
OPLP/ 3WC/Carb	3	3	-	5	4	-	-	-	2	17
OPLP/Oxid/Carb	93	11	-	24	35	1	4	-	30	198
OPLP/None/Carb	-	-	-	-	-	-	-	-	5	5
All Normals	372	30	47	196	346	6	107	1	114	1219
High-Emitters										
CLLP/OX3W/Carb	14	-	-	2	6	-	-	-	2	24
CLLP/ 3WC/Carb	3	-	-	1	11	-	-	-	7	22
CLLP/OX3W/FI	-	-	1	-	-	-	-	-	-	1
CLLP/ 3WC/FI	-	-	-	1	-	-	-	-	-	1
OPLP/OX3W/Carb	8	-	-	-	10	-	-	-	-	18
OPLP/ 3WC/Carb	-	-	-	-	-	-	-	-	1	1
OPLP/Oxid/Carb	-	-	-	-	-	-	-	-	2	2
All Highs	25	0	1	4	27	0	0	0	12	69
Super-Emitters										
CLLP/OX3W/Carb	3	-	-	-	1	-	-	-	-	4
All Vehicles	400	30	48	200	374	6	107	1	126	1292

TABLE 3

Normal-Emitter Deterioration Factors for Non-Tampered Light-Duty Vehicles by Bag and Technology Group

	Deterioration Factors (gm/mi/10k-miles) by Technology Type		
	CLLP/3W	OPLP/3W	Oxidation
FTP (All)			
HC	0.04998	0.04507	0.02681
CO	0.6459	0.1713	0.4638
NOx	0.09534	0.07692	0.01821
FTP Bag 1			
HC1	0.11907	0.08728	0.09240
CO1	1.6554	0.7530	1.4863
NO1	0.09324	0.06917	0.00121
FTP Bag 2			
HC2	0.03304	0.02780	0.00911
CO2	0.3777	0.0000	0.2053
NO2	0.08205	0.07539	0.02323
FTP Bag 3			
HC3	0.03067	0.04670	0.01129
CO3	0.3988	0.2001	0.1824
NO3	0.12259	0.08572	0.02156

TABLE 4

Normal Emitter Zero-Mile Intercepts
for Light-Duty Gasoline Vehicles

Technology	Zero-Mile Intercepts (gm/mi)					
	Closed-Loop OX3W*			Closed-Loop 3WC*		
Model Years	1981+	1981	1982+	1981+	1981	1982+
CO Standard	3.4	7.0	7.0	3.4	7.0	7.0
FTP HC	0.2260	0.3056	0.2513	0.2260	0.3048	0.2041
FTP CO	1.948	3.201	2.994	1.948	4.277	2.824
FTP NOx	0.5328	0.6942	0.6717	0.5328	0.5433	0.5510
Bag 1 HC	0.5271	0.8780	0.7141	0.5271	0.7798	0.6145
Bag 1 CO	5.550	10.927	10.092	5.550	10.925	6.710
Bag 1 NOx	1.0096	1.0788	1.0926	1.0096	1.1605	1.0958
Bag 2 HC	0.1117	0.1056	0.0951	0.1117	0.1370	0.0771
Bag 2 CO	0.612	0.535	0.475	0.612	2.133	1.654
Bag 2 NOx	0.3870	0.5310	0.5108	0.3870	0.3938	0.3864
Bag 3 HC	0.2127	0.2521	0.1959	0.2127	0.2621	0.1333
Bag 3 CO	1.748	2.405	2.392	1.748	3.302	2.091
Bag 3 NOx	0.5170	0.7127	0.6573	0.5170	0.3597	0.4203

Technology	Open-Loop 3-Way Catalyst			Oxidation Catalyst		
Model Years	1981+	1981	1982+	1981+	1981	1982+
CO Standard	3.4	7.0	7.0	3.4	7.0	7.0
FTP HC	0.3229	0.3700	0.3435	0.2768	0.2220	0.1801
FTP CO	2.823	5.775	4.395	2.507	3.398	2.787
FTP NOx	0.5626	0.4101	0.6933	0.7592	0.6735	0.6658
Bag 1 HC	0.6930	0.5573	0.5744	0.7663	0.5366	0.5011
Bag 1 CO	7.665	9.568	10.212	6.867	11.870	9.454
Bag 1 NOx	0.8423	0.7819	0.8957	1.0717	1.0702	1.0896
Bag 2 HC	0.1803	0.2705	0.2319	0.1195	0.1178	0.0967
Bag 2 CO	0.542	3.535	1.821	1.001	0.722	1.125
Bag 2 NOx	0.4506	0.2722	0.6504	0.5935	0.4874	0.4115
Bag 3 HC	0.3136	0.4175	0.3795	0.2087	0.1786	0.1034
Bag 3 CO	3.199	6.827	4.836	2.070	2.048	0.958
Bag 3 NOx	0.5628	0.3909	0.6231	0.8380	0.7283	0.8221

*Includes both carbureted and fuel injected vehicles.

TABLE 5

Mean Emission Levels of High and Super Emitters

	Mean Emission Levels (gm/mi)			
	High Emitters		Super Emitters	
	HC	CO	HC	CO
Closed-Loop Carb				
FTP	2.2997	39.137	14.132	193.23
Bag 1	4.6408	61.181	30.937	181.02
Bag 2	1.7954	35.503	10.867	210.72
Bag 3	1.4857	29.354	7.508	169.22
Closed-Loop FI				
FTP	2.3556	38.212	10.560	191.72
Bag 1	4.2419	53.030	8.090	170.45
Bag 2	1.9737	36.496	12.645	215.45
Bag 3	1.6574	30.292	8.460	162.55
Open-Loop 3-Way				
FTP	2.2556	34.607		
Bag 1	3.6050	50.422		
Bag 2	1.7850	30.528		
Bag 3	2.1094	30.361		

Note: There were no Super emitters observed in the OPLP 3-Way category sample. No High or Super emitters were observed in the Oxidation Catalyst category sample.

TABLE 6

Technology Distribution by Model Year

Model Years	Projected Fleet Percentage (%)			
	1981		1982	
CO Standard	3.4	7.0	3.4	7.0
Technology				
CLLP/OX3W/Carb	23.1	15.1	3.6	32.7
CLLP/ 3WC/Carb	4.5	18.1	3.8	12.7
CLLP/OX3W/FI	1.0	1.9	1.4	2.3
CLLP/ 3WC/FI	2.3	4.2	5.6	9.0
OPLP 3-Way	7.6	7.5	2.3	12.8
OPLP Oxidation	10.3	4.4	10.1	3.7
Percentage	48.8	51.2	26.8	73.2

Model Years	1983	1984	1985-1986	1987-1989	1990+
Technology					
CLLP/OX3W/Carb	45.3	43.4	23.5	11.2	4.0
CLLP/ 3WC/Carb	2.1	11.9	11.1	8.5	6.2
CLLP/OX3W/FI	27.6	40.0	61.0	79.5	88.8
CLLP/ 3WC/FI	-	-	-	-	-
OPLP 3-Way	13.1	4.7	4.4	0.8	1.0
OPLP Oxidation	11.9	-	-	-	-

TABLE 7

Combined Sample I/M Short Test Failure Rate Summary

ICO/IHC Cutpoints	Emission Category	Pass Short Test		Fail Short Test	
		Pass FTP	Fail FTP	Pass FTP	Fail FTP
Idle Test					
0.5%/100ppm	Normal	661	411	7	26
	High	-	32	-	25
	Super	-	1	-	3
	All	661 (57%)	444 (38%)	7 (0.6%)	54 (4.6%)
1.2%/220ppm	Normal	666	421	2	16
	High	-	40	-	17
	Super	-	1	-	3
	All	666 (57%)	462 (40%)	2 (0.2%)	36 (3.1%)
3.0%/300ppm	Normal	666	432	2	5
	High	-	47	-	10
	Super	-	1	-	3
	All	666 (57%)	480 (41%)	2 (0.2%)	18 (1.5%)
2500/Idle Test					
0.5%/100ppm	Normal	648	401	20	36
	High	-	25	-	32
	Super	-	1	-	3
	All	648 (56%)	427 (37%)	20 (1.7%)	71 (6.1%)
1.2%/220ppm	Normal	656	414	12	23
	High	-	34	-	23
	Super	-	1	-	3
	All	656 (56%)	449 (39%)	12 (1.0%)	49 (4.2%)
3.0%/300ppm	Normal	662	431	6	6
	High	-	43	-	14
	Super	-	1	-	3
	All	662 (57%)	475 (41%)	6 (0.5%)	23 (2.0%)
Loaded/Idle Test					
0.5%/100ppm	Normal	647	383	21	54
	High	-	16	-	41
	Super	-	1	-	3
	All	647 (55%)	400 (34%)	21 (1.8%)	98 (8.4%)
1.2%/220ppm	Normal	659	419	9	18
	High	-	28	-	29
	Super	-	1	-	3
	All	659 (57%)	448 (38%)	9 (0.8%)	50 (4.3%)
3.0%/300ppm	Normal	664	429	4	8
	High	-	39	-	18
	Super	-	1	-	3
	All	664 (57%)	469 (40%)	4 (0.3%)	29 (2.5%)

TABLE 8

Mean Emission Levels of High and Super Emitter Vehicles Failing I/M Short Tests

ICO/IHC Cutpoints	Sample Size	Mean Emissions (gm/mi) HC	Mean Emissions (gm/mi) CO	Emissions Identified (IDR) HC	Emissions Identified (IDR) CO
All Highs	57	2.2558	37.086		
Fail Idle Test					
0.5%/100ppm	25	2.6492	46.232	0.515	0.547
1.2%/220ppm	17	2.8659	55.949	0.379	0.450
3.0%/300ppm	10	2.8770	59.796	0.224	0.283
2500/Idle Test					
0.5%/100ppm	32	2.5834	48.378	0.643	0.732
1.2%/220ppm	23	2.8191	57.501	0.504	0.626
3.0%/300ppm	14	3.0564	64.024	0.333	0.424
Loaded/Idle Test					
0.5%/100ppm	41	2.3315	43.158	0.743	0.837
1.2%/220ppm	29	2.5383	51.922	0.572	0.712
3.0%/300ppm	18	2.8333	57.057	0.397	0.486
All Supers	4	14.132	193.23		
Failing All I/M Short Tests					
Carbureted	3	10.557	212.77	0.560	0.826
Fuel-Injected*	2	10.560	191.72	1.000	1.000

* Only two of the Super emitters were judged as possible for fuel-injected vehicles.

APPENDIX

Tech IV Credit Model
Software Program Listing

```
      CC
      CC
      CC          THIS IS THE APPENDIX 4 PROGRAM DEVELOPED FOR
      CC                              MOBILE3
      CC
      CC
      CC    THIS PROGRAM CALCULATES I/M BENEFITS FOR THE POST-1980 FLEET.
      CC                    EITHER ANNUAL AND BIENNIAL
      CC
      CC                          **  SIX TECHS  **
      CC
      CC                    **  SEVEN MODEL YEAR GROUPS  **
      CC
      CC                          (UPDATED 8/23/84)
      CC
      CC
      CC    ESTABLISH VARIABLES.
      CC
      CC
      CC    BI = 1 : 1/3/5 SCHEDULE.
      CC    BI = 2 : 2/4/6 SCHEDULE.
      CC    BI = 3 : ANNUAL SCHEDULE.
      CC
      CC    STD = 1 : 1981 MODEL YEAR     4 : 1984      7 : 1990+
      CC    STD = 2 : 1982                5 : 1985-6
      CC    STD = 3 : 1983                6 : 1987-9
      CC
            INTEGER BI,BY,P,B,T,IDR,LAST,YR,AGE1ST,IAGE,NAGE,STD,IY,STP,INCR
            INTEGER IYR,IP,IB,IT,D,II,JJ,KK,LL,J
            REAL KINK
      CC
      CC    "KINK" IS THE KINK IN THE HIGH EMISSION DETERIORATION RATE
      CC       AFTER 50,000 MILES.  IF KINK=1, THERE IS NO KINK.
      CC    IF KINK=2, THE DETERIORATION RATE DOUBLES AFTER 50K MILES.
      CC
            KINK=2.0
            BI = 3
      CC
            COMMON/INPUT/SH0,SS0,GH,GS,ES0,DS,EN00,DN,EH0,DH
            COMMON/FRC/FRAC
            COMMON/REG/EWOC(20,2,3,5,9),EWC(20,2,3,5,9)
            COMMON/TECH/EWO(20,2,5,6,9),EW(20,2,5,6,9)
            COMMON/BENE/ CA(20,20,2,5),CZ(20,20,2,5),CWO(20,2,5),INT
            COMMON/BAG/ZML2(5,7,3),DET2(5,7,3)
            COMMON/ODOM/RATE,MILE,SRATE,MDIF
            COMMON/MACC/JMILE
            COMMON/IMS/INSP,FINSP,STD,IDR,IY,T,B
            COMMON/BASE/EN,EH,ES,HIGH,SUPER,WN
      CC
            LOGICAL INSP
            LOGICAL FINSP(3)
      CC
            REAL SRATE(2,2),RATE(9,2),MILE(20)
            REAL SUMX(2),SUMXX(2),SUMY(2),SUMXY(2)
            REAL HIGH(20,2),INT(2,5,6),SUPER(20,2)
            REAL GHI,GH2,GH3
            REAL SH0(2,5,6),SS0(2,5,6),GH(2,5,6),GS(2,5,6)
```

```
      REAL ES0(2,5,6),EN0(2,5,6),EH0(2,5,6),EN00(2,5,6,3)
      REAL DS(2,5,6), DN(2,5,6), DH(2,5,6)
      REAL EW0,EW,FRAC(6,9)
      REAL MDIF(20)
      REAL ES(20,2),EN(20,2),EH(20,2)
      REAL WN(20,2),WN0(2,5,5),DWN(2,5,5),ENZ(20,2),ENA(20,2)
      REAL SZ(20,9,5),SA(20,9,5),HZ(20,9,5),HA(20,9,5)
      REAL NZ(20,9,5),NA(20,9,5),SS,SH,SN
CC
CC....RATE IS THE EFFECTIVE IDENTIFICATION RATE OF HIGHS
CC      FOR EACH TEST/CUTPOINT COMBO AND BY POLLUTANT
CC
CC....CALCULATE MILEAGE BETWEEN EACH ONE YEAR INTERVAL
CC
      MDIF(1) = MILE(1)
CC
      DO 10 YR=2,20
        MDIF(YR) = MILE(YR) - MILE(YR-1)
   10 CONTINUE
CC
CC....FIRST LOOP IS IDR
CC
CC      IDR      TEST      CUTPOINTS (HC/CO)
CC      ---- ----------  -----------------
CC       1       IDLE          .5/100
CC       2       IDLE         1.2/220
CC       3       IDLE         3.0/300
CC       4     2500/IDLE       .5/100
CC       5     2500/IDLE      1.2/220
CC       6     2500/IDLE      3.0/300
CC       7      LOADED         .5/100
CC       8      LOADED        1.2/220
CC       9      LOADED        3.0/300
CC
      DO 600 STD=1,7
      DO 600 IDR=1,9
CC
CC
CC
CC.... THIS NEXT LOOP IS FOR 1981 & 1982 MODEL YEAR GROUPS
CC        SO THAT THE PROGRAM WILL LOOP FOR 3.4 AND 7.0
CC
        INCR=1
        STP=1
      IF (STD.NE.1) GO TO 30
        INCR=1
        STP=2
       GO TO 40
   30 IF (STD.NE.2) GO TO 40
        INCR=2
        STP=3
CC
   40 DO 440 IY=1,STP,INCR
CC
CC
CC*** THIS IS THE FIRST PART OF THE MOBILE3.APPENDIX4
CC    MODEL.  THIS PART WILL CALCULATE THE RELATIVE SIZE
CC    OF THE FLEET AND OTHER BASIC NON-I/M PARAMETERS.
```

```
117     CC
118     CC
119     CC....RETRIEVE THE CORRECT DATA FOR NORMALS FROM BLOCK DATA
120     CC          DEPENDING UPON MODEL YEAR AND 3.4/7.0 LOOP
121     CC
122           LL = 1
123           IF(STD.EQ.1.AND.IY.EQ.1) LL=1
124           IF(STD.EQ.1.AND.IY.EQ.2) LL=2
125           IF(STD.EQ.2.AND.IY.EQ.2) LL=3
126     CC
127            DO 50 II=1,2
128               DO 50 JJ=1,5
129                  DO 50 KK=1,6
130            ENO(II,JJ,KK) = ENOO(II,JJ,KK,LL)
131        50 CONTINUE
132     CC
133     CC
134     CC....THE NEXT LOOP IS BY TECHNOLOGY
135     CC
136     CC    TECH = 1 : OXIDATION/3-WAY CATALYST, CLOSED-LOOP, CARBURATED.
137     CC    TECH = 2 : 3-WAY CATALYST, CLOSED-LOOP, CARBURATED.
138     CC    TECH = 3 : OXIDATION/3-WAY CATALYST, CLOSED-LOOP, FUEL INJECTED.
139     CC    TECH = 4 : 3-WAY CATALYST, CLOSED-LOOP, FUEL INJECTED.
140     CC    TECH = 5 : 3-WAY CATALYST, OPEN-LOOP, ALL
141     CC    TECH = 6 : OXIDATION CATALYST, ALL
142     CC
143           DO 420 T=1,6
144     CC
145     CC
146     CC....LOOP BY BAG (1=FTP; 2=BAG1; 3=BAG2; 4=BAG3; 5=BAGGED IDLE)
147     CC
148           DO 410 B=1,4
149     CC
150     CC....CALCULATE CATAGORY SIZE AT ZERO MILE POINTS
151     CC
152     CC
153           DO 100 P=1,2
154           SS = SSO(P,B,T)
155           SH = SHO(P,B,T)
156           SN = 1.0 - SS - SH
157     CC
158     CC....CALCULATE FLEET ZERO MILE EMISSIONS
159     CC
160              INT(P,B,T) = SS * ESO(P,B,T)
161          *             + SH * EHO(P,B,T)
162          *             + SN * ENO(P,B,T)
163       100 CONTINUE
164     CC
165     CC....CALCULATE EMISSION LEVELS
166     CC       FOR EACH CATAGORY BY VEHICLE AGE
167     CC
168           DO 120 YR=1,20
169     CC
170           DO 110 P=1,2
171     CC
172     CC....SET NON-I/M EMISSION LEVELS FOR THE CATEGORIES.
173     CC
174           ES(YR,P) = ESO(P,B,T) + ( DS(P,B,T) * MILE(YR) )
```

```
175           EH(YR,P) = EHO(P,B,T) + ( DH(P,B,T) * MILE(YR) )
176           EN(YR,P) = ENO(P,B,T) + ( DN(P,B,T) * MILE(YR) )
177     CC
178     CC....SET WITH-I/M LEVELS FOR "NORMALS"
179     CC
180           WN(YR,P) = ENO(P,B,T) + ( DN(P,B,T) * MILE(YR) )
181     CC
182     CC....COMPUTE NUMBER OF "HIGH" EMITTERS WITHOUT INSPECTION PROGRAM.
183     CC
184           HIGH(YR,P) = SHO(P,B,T) + GH(P,B,T) * MILE(YR)
185     CC
186     CC....THIS CODE "KINKS" THE INCREASE IN "HIGH" EMITTERS
187     CC    AFTER 50,000 MILES.
188     CC
189           IF(MILE(YR-1).GT.5.0)
190          * HIGH(YR,P)=HIGH(YR-1,P)+KINK*GH(P,B,T)*MDIF(YR)
191     CC
192     CC....THIS ASSUMES LINEAR INCREASE IN NUMBER OF "SUPER" EMITTERS
193     CC
194           SUPER(YR,P) = SSO(P,B,T) + GS(P,B,T) * MILE(YR)
195     CC
196     CC....COMPUTE WITHOUT-I/M SIZES OF CATAGORIES
197     CC
198           SH = HIGH(YR,P)
199           SS = SUPER(YR,P)
200           SN = 1.0 - SS - SH
201     CC
202     CC....COMPUTE WITHOUT-I/M COMPOSITE EMISSION LEVELS..
203     CC
204           CWO(YR,P,B) = SS * ES(YR,P)
205          *            + SH * EH(YR,P)
206          *            + SN * EN(YR,P)
207     CC
208       110 CONTINUE
209     CC
210       120 CONTINUE
211     CC
212           CALL IMSUB(BI,KINK)
213           CALL BENEFT(T,B,IDR,BI)
214     CC
215       410 CONTINUE
216     CC
217       420 CONTINUE
218     CC
219           CALL MUSCH(STD,IY,IDR)
220     CC
221       440 CONTINUE
222     CC
223           IF(IDR.GT.1) GO TO 600
224           CALL BAGF(STD)
225     CC
226       600 CONTINUE
227     CC
228     CC...CALCULATE NOX EMISSIONS
229     CC
230           CALL NOXEF
231     CC
232     CC...WRITE OUT TABLES
```

```
      CC
            CALL OUTPUT
      CC
             STOP
             END
```

```
      SUBROUTINE IMSUB(BI,KINK)
CC
CC      IN THIS SECTION THE NUMBER OF "HIGHS" AND "SUPERS"
CC      REMAINING AFTER I/M IS DETERMINED AND I/M EMISSION
CC      LEVELS ARE CALCULATED FOR THE "SAWTEETH".
CC
      COMMON/ODOM/RATE,MILE,SRATE,MDIF
      COMMON/MACC/JMILE
      COMMON/IMS/INSP,FINSP,STD,IDR,IY,T,B
      COMMON/BASE/EN,EH,ES,HIGH,SUPER,WN
      COMMON/BENE/ CA(20,20,2,5),CZ(20,20,2,5),CWO(20,2,5),INT
      COMMON/INPUT/SHO,SSO,GH,GS,ESO,DS,ENOO,DN,EHO,DH
CC
      LOGICAL INSP,FINSP(3)
      INTEGER AGE1ST,BY,P,BI,STD,IDR,IY,T,B,YR
CC
      REAL KINK
      REAL EN(20,2),EH(20,2),ES(20,2),WN(20,2)
      REAL HIGH(20,2),SUPER(20,2)
      REAL SHO(2,5,6),SSO(2,5,6),GH(2,5,6),GS(2,5,6)
      REAL ENOO(2,5,6,3),DN(2,5,6)
      REAL EHO(2,5,6),DH(2,5,6)
      REAL ESO(2,5,6),DS(2,5,6)
      REAL MILE(20),RATE(9,2),SRATE(2,2),MDIF(20)
      REAL NZ(20,9,5),NA(20,9,5)
      REAL HZ(20,9,5),HA(20,9,5)
      REAL SZ(20,9,5),SA(20,9,5)
      REAL ENZ(20,2),ENA(20,2)
CC
CC....INSP USED TO DETERMINE IF AN INSPECTION OCCURS THAT YEAR.
CC
      INSP = FINSP(BI)
      AGE1ST = 1
CC
CC    VARIABLE 'BY' REPRESENTS YEARS SINCE PROGRAM START
CC    VARIABLE 'YR' REPRESENTS AGE OF VEHICLE
CC
      DO 290 BY=1,19
CC
       YR = AGE1ST + BY - 1
CC
      DO 280 P=1,2
CC
CC.....CATEGORY SIZES BEFORE AND AFTER INSPECTION
CC
CC      EZ = SIZE OF "HIGH" CATAGORY BEFORE INSPECTION
CC      HA = SIZE OF "HIGH" CATAGORY AFTER  INSPECTION
CC
CC      SZ = SIZE OF "SUPER" CATAGORY BEFORE INSPECTION
CC      SA = SIZE OF "SUPER" CATAGORY AFTER  INSPECTION
CC
     SIDR = SRATE(P,1)
     IF(T.GT.2) SIDR = SRATE(P,2)

CC
     IF( BY.GT.1 ) GO TO 130
CC
CC.....THE FIRST INSPECTION YEAR
```

```
295     CC
296           HZ(YR,IDR,P) = HIGH(YR,P)
297           HA(YR,IDR,P) = HIGH(YR,P) * ( 1.0 - RATE(IDR,P) )
298           IF(.NOT.INSP) HA(YR,IDR,P) = HZ(YR,IDR,P)
299     CC
300           SZ(YR,IDR,P) = SUPER(YR,P)
301           SA(YR,IDR,P) = SUPER(YR,P) * ( 1.0 - SIDR )
302           IF(.NOT.INSP) SA(YR,IDR,P) = SZ(YR,IDR,P)
303     CC
304           IF( YR.EQ.1 ) GO TO 130
305     CC
306             CA(AGE1ST,YR-1,P,B) = CWO(YR-1,P,B)
307     CC
308     CC...LIKELIHOOD OF OCCURENCE AND GROWTH OF "HIGH" CATEGORY.
309     CC
310     CC   GHI = GROWTH RATE OF "HIGH" CATAGORY AFTER I/M REPAIRS
311     CC
312       130 GROWTH = GH(P,B,T)
313           IF(MILE(YR-1).GT.5.0) GROWTH=KINK*GH(P,B,T)
314     CC
315           GHI = GROWTH
316          *    * (1.0-HA(YR,IDR,P)-SA(YR,IDR,P))
317          *    / (1.0-HIGH(YR,P)-SUPER(YR,P))
318     CC
319     CC....COMPUTE NUMBER OF "HIGH" EMITTERS IN THE NEXT YEAR.
320     CC
321           HZ(YR+1,IDR,P) = HA(YR,IDR,P) + GHI * MDIF(YR+1)
322           IF(HZ(YR+1,IDR,P).GT.HIGH(YR+1,P)) HZ(YR+1,IDR,P)=HIGH(YR+1,P)
323     CC
324           HA(YR+1,IDR,P) = HIGH(YR+1,P) * (1.0 - RATE(IDR,P))
325           IF(INSP.AND.BI.NE.3) HA(YR+1,IDR,P) = HZ(YR+1,IDR,P)
326     CC
327     CC....COMPUTE NUMBER OF "SUPER" EMITTERS IN THE NEXT YEAR.
328     CC    GROWTH RATE OF SUPERS AFTER I/M IS SAME AS WITHOUT I/M.
329     CC
330           SZ(YR+1,IDR,P) = SA(YR,IDR,P) + GS(P,B,T)*MDIF(YR+1)
331           SA(YR+1,IDR,P) = SUPER(YR,P) * ( 1.0 - SIDR )
332           IF(INSP.AND.BI.NE.3) SA(YR+1,IDR,P) = SZ(YR+1,IDR,P)
333     CC
334     CC...."NORMAL" CATEGORY SIZE BEFORE AND AFTER INSPECTION
335     CC
336           NZ(YR,IDR,P) = 1.00 - SZ(YR,IDR,P) - HZ(YR,IDR,P)
337           NA(YR,IDR,P) = 1.00 - SA(YR,IDR,P) - HA(YR,IDR,P)
338     CC
339     CC....COMPUTE EMISSIONS BEFORE AND AFTER I/M FOR "NORMALS"
340     CC    ASSUMES THAT WITH I/M NORMALS WILL PRODUCE EMISSION REDUCTIONS.
341     CC
342           IF(.NOT.INSP.AND.BY.EQ.1) GO TO 140
343           IF(INSP.AND.BY.LE.2) GO TO 150
344           GO TO 160
345     CC
346      140  ENZ(YR,P) = EN(YR,P)
347           ENA(YR,P) = EN(YR,P)
348           GO TO 180
349     CC
350      150  ENZ(YR,P) = EN(YR,P)
351           ENA(YR,P) = WN(YR,P)
```

```
352           GO TO 180
353      CC
354       160  ENZ(YR,P) = ENA(YR-1,P) + DN(P,B,T) * MDIF(YR)
355           ENA(YR,P) = WN(YR,P)
356      CC
357       180  CONTINUE
358      CC
359      CC
360      CC....COMPOSITE EMISSIONS BEFORE AND AFTER INSPECTION.
361      CC
362      CC
363           CZ(AGE1ST,YR,P,B) = SZ(YR,IDR,P)*ES(YR,P)
364          *                  + NZ(YR,IDR,P)*ENZ(YR,P)
365          *                  + HZ(YR,IDR,P)*EH(YR,P)
366           CA(AGE1ST,YR,P,B) = SA(YR,IDR,P)*ES(YR,P)
367          *                  + NA(YR,IDR,P)*ENA(YR,P)
368          *                  + HA(YR,IDR,P)*EH(YR,P)
369           IF(.NOT.INSP) CA(AGE1ST,YR,P,B) = CZ(AGE1ST,YR,P,B)
370      CC
371      CC
372      CC....EMISSIONS AT THE 20TH YEAR (BOUNDARY CONDITION).
373      CC
374      CC
375           IF(YR.GT.1) GO TO 280
376           G20 = KINK * GH(P,B,T)
377          *    * (1.0-HA(19,IDR,P)-SA(19,IDR,P))
378          *    / (1.0-HIGH(19,P)-SUPER(19,P))
379           HZ(20,IDR,P) = HA(19,IDR,P) + G20 * MDIF(20)
380           SZ(20,IDR,P) = SA(19,IDR,P) + GS(P,B,T) * MDIF(20)
381           NZ(20,IDR,P) = 1.0 - SZ(20,IDR,P) - HZ(20,IDR,P)
382      CC
383           CZ(AGE1ST,20,P,B) = SZ(20,IDR,P)*ES(20,P)
384          *                  + NZ(20,IDR,P)*EN(20,P)
385          *                  + HZ(20,IDR,P)*EH(20,P)
386      CC
387        280 CONTINUE
388      CC
389           IF(BI.NE.3) INSP = .NOT. INSP
390      CC
391        290 CONTINUE
392      CC
393        999 RETURN
394           END
```

```
      SUBROUTINE BENEFT(T,B,IDR,BI)
CC
CC
CC    THIS SECTION CALCULATES REDUCTIONS BY COMPARING EMISSIONS
CC    WITH AND WITHOUT I/M ON JANUARY 1ST DATES .
CC    SINCE MODEL YEAR INTRODUCTION IS ON OCTOBER 1ST., THIS
CC    REQUIRES A 75/25 STAGGERING.
CC
CC
      COMMON/BENE/ CA(20,20,2,5),CZ(20,20,2,5),CWO(20,2,5),INT
      COMMON/TECH/ EWO(20,2,5,6,9),EW(20,2,5,6,9)
CC
      REAL EWO,EW,INT(2,5,6)
      INTEGER AGE1ST,BY,P,B,T,IDR,BI,YR,LAST
CC
CC
      AGE1ST = 1
CC
      DO 350 BY=1,19
        YR = AGE1ST + BY - 1
      DO 350  P=1,2
CC
      IF(AGE1ST.GT.1) GO TO 310
      IF(YR.GT.1) GO TO 300
CC
       EW(1,P,B,T,IDR) = .75*(.625*CZ(AGE1ST,1,P,B) + .375*INT(P,B,T))
     *         + .25*(.875*CA(AGE1ST,1,P,B) + .125*CZ(AGE1ST,2,P,B) )
       EWO(1,P,B,T,IDR) = .75*(.625*CWO(1,P,B) + .375*INT(P,B,T))
     *         + .25*(.875*CWO(1,P,B) + .125*CWO(2,P,B))
C      GO TO 340
       GO TO 350
CC
  300  EW(YR,P,B,T,IDR) = .75*(.625*CZ(AGE1ST,YR,P,B)
     *             + .375*CA(AGE1ST,YR-1,P,B) )
     *             + .25*(.875*CA(AGE1ST,YR,P,B)
     *             + .125*CZ(AGE1ST,YR+1,P,B) )
       GO TO 330
CC
  310 GO TO (300,7,8,7,8,7,8,7,8,7,8,7,8,7,8,7,8,7),AGE1ST
CC
    7 IF(BI.EQ.1) IAGE = AGE1ST + 1
      IF(BI.EQ.1) NAGE = AGE1ST - 1
      IF(BI.EQ.2) IAGE = AGE1ST - 1
      IF(BI.EQ.2) NAGE = AGE1ST - 1
      GO TO 320
CC
    8 IF(BI.EQ.1) IAGE = AGE1ST
      IF(BI.EQ.1) NAGE = AGE1ST
      IF(BI.EQ.2) IAGE = AGE1ST
      IF(BI.EQ.2) NAGE = AGE1ST - 2
CC
  320 IF(BI.EQ.3) IAGE = AGE1ST
      IF(BI.EQ.3) NAGE = AGE1ST - 1
CC
       EW(YR,P,B,T,IDR) = .75*(.625*CZ(NAGE,YR,P,B)
     *          +  .375*CA(NAGE,YR-1,P,B)) + .25*(.875*CA(IAGE,YR,P,B)
     *           + .125*CZ(IAGE,YR+1,P,B))
```

```
452      CC
453        330  EWO(YR,P,B,T,IDR) = .75*(.625*CWO(YR,P,B) + .375*CWO(YR-1,P,B))
454           *              + .25 *(.875*CWO(YR,P,B) + .125*CWO(YR+1,P,B))
455      CC
456      CC
457        350 CONTINUE
458      CC
459      CC
460            RETURN
461            END
```

```
462           SUBROUTINE MUSCH(STD,IY,IDR)
463     CC
464     CC    THIS SECTION COMBINES EMISSION STANDARD CATEGORIES AND
465     CC    TECHNOLOGIES INTO MODEL YEAR EMISSION LEVELS.
466     CC
467           COMMON/REG/EWOC(20,2,3,5,9),EWC(20,2,3,5,9)
468           COMMON/TECH/EWO(20,2,5,6,9),EW(20,2,5,6,9)
469           COMMON/FRC/FRAC
470           COMMON/OUT/RED(19,2,7,3,3),ZMLC(5,7,3),DETC(5,7,3)
471     CC
472           REAL EWO,EW,OC(6),WC(6),FRAC(6,9)
473           INTEGER ICUTS,ITEST,IDR,B,IP,IT,IYR,IY,STD,D
474     CC
475     CC    DEFINITIONS:
476     CC
477     CC    EWOC : WITHOUT I/M EMISSION LEVELS
478     CC    EWC  : WITH I/M EMISSION LEVELS
479     CC    RED  : REDUCTION IN EMISSIONS DUE TO I/M
480     CC
481     CC  ITEST = 1 : IDLE TEST
482     CC          2 : IDLE/2500
483     CC          3 : LOADED/IDLE
484     CC
485     CC  ICUTS = 1 : 0.5% ICO / 100 PPM IHC
486     CC          2 : 1.2% ICO / 220 PPM IHC
487     CC          3 : 3.0% ICO / 300 PPM IHC
488     CC
489     CC....DECODE IDR INTO CUTPOINT AND TEST TYPES
490     CC
491           ITEST = 1
492           ICUTS = IDR
493           IF(IDR.GT.3) ITEST=2
494           IF(IDR.GT.6) ITEST=3
495           IF(IDR.GT.3) ICUTS=IDR-3
496           IF(IDR.GT.6) ICUTS=IDR-6
497     CC
498     CC....D IS USED FOR RETRIEVING TECHNOLOGY FRACTIONS (FRAC)
499     CC
500           D = STD + 2
501           IF (STD.EQ.1.AND.IY.EQ.1) D=1
502           IF (STD.EQ.1.AND.IY.EQ.2) D=2
503           IF (STD.EQ.2.AND.IY.EQ.1) D=3
504           IF (STD.EQ.2.AND.IY.EQ.2) D=4
505     CC
506     CC
507     CC....LOOP BY BAG
508     CC
509           DO 200 B=1,4
510     CC
511     CC....COMBINE TECHNOLOGIES FOR EACH POLLUTANT AND YEAR
512     CC
513           DO 130 IYR=1,19
514           DO 130 IP=1,2
515     CC
516                DO 120 IT=1,6
517     CC
518                OC(IT)= FRAC(IT,D)/100.0 * EWO(IYR,IP,B,IT,IDR)
```

```
519                   WC(IT)= FRAC(IT,D)/100.0 * EW(IYR,IP,B,IT,IDR)
520      CC
521        120        CONTINUE
522      CC

523                EWOC(IYR,IP,IY,B,IDR) = OC(1)+OC(2)+OC(3)+OC(4)+OC(5)+OC(6)
524                EWC(IYR,IP,IY,B,IDR)  = WC(1)+WC(2)+WC(3)+WC(4)+WC(5)+WC(6)
525      CC
526        130  CONTINUE
527      CC
528      CC...COMBINE 3.4 AND 7.0 SCENARIOS FOR 81 & 82 MODEL YEAR
529      CC
530            IF(D.GE.5)              GO TO 160
531            IF(D.EQ.2.OR.D.EQ.4)    GO TO 140
532                                    GO TO 200
533      CC
534        140 DO 150 IP=1,2
535            DO 150 IYR=1,19
536             EWOC(IYR,IP,IY,B,IDR)=EWOC(IYR,IP,IY,B,IDR)+EWOC(IYR,IP,1,B,IDR)
537             EWC(IYR,IP,IY,B,IDR)=EWC(IYR,IP,IY,B,IDR)+EWC(IYR,IP,1,B,IDR)
538        150 CONTINUE
539      CC
540      CC....CALCULATE NON-I/M REGRESSION
541      CC
542        160 CALL REGR(IY,IDR,B,STD)
543      CC
544      CC....CALCULATE I/M REDUCTION
545      CC
546            IF(B.NE.1) GO TO 200
547            DO 170 IP=1,2
548            DO 170 IYR=1,19
549            RED(IYR,IP,STD,ICUTS,ITEST) = ( EWOC(IYR,IP,IY,1,IDR)
550           *                              -   EWC(IYR,IP,IY,1,IDR) )
551           *                              /   EWOC(IYR,IP,IY,1,IDR)
552        170 CONTINUE
553      CC
554        200 CONTINUE
555      CC
556            RETURN
557            END
```

```
      SUBROUTINE REGR(IY,IDR,B,STD)
CC
CC....THIS SUBROUTINE CALCULATES WEIGHTED REGRESSION EQUATION
CC            FOR THE EMISSION FACTOR LINES
CC
      COMMON/REG/EWOC(20,2,3,5,9),EWC(20,2,3,5,9)
      COMMON/BAG/ZML2(5,7,3),DET2(5,7,3)
      COMMON/ODOM/RATE,MILE,SRATE,MDIF
      COMMON/WRG/WGT
      COMMON/MACC/JMILE
CC
      REAL JMILE(19),WGT(20)
      REAL SUMX,SUMY,SUM1,SUM2,XBAR,YBAR
      REAL MILE(20),RATE(9,2),SRATE(2,2),MDIF(20)
      REAL ZML1,DET1
CC
      INTEGER B,IDR,IY,T,STD
CC
      IF(IDR.GT.1) GO TO 999
CC
      DO 100 IP=1,2
CC
      SUMX  = 0.0
      SUMY  = 0.0
      SUMXY = 0.0
      SUMXX = 0.0
CC
      DO 60 IYR=1,19
CC
      EM = EWOC(IYR,IP,IY,B,IDR)
CC
      SUMX  = SUMX  + ( WGT(IYR) * JMILE(IYR) )
      SUMY  = SUMY  + ( WGT(IYR) * EM )
      SUMXY = SUMXY + ( WGT(IYR) * JMILE(IYR) * EM )
      SUMXX = SUMXX + ( WGT(IYR) * (JMILE(IYR)**2) )
CC
   60 CONTINUE
CC
CC
      SUM1 = SUMXY - SUMX * SUMY
      SUM2 = SUMXX - SUMX**2
CC
      DET1 = SUM1 / SUM2
      ZML1 = SUMY - DET1 * SUMX
CC
CC....ORDINARY REGRESSION
CC
      ZML2(B,STD,IP) = ZML1
      DET2(B,STD,IP) = DET1
CC
      IF(ZML2(B,STD,IP).GE.0.0) GO TO 100
CC
CC....REGRESSION FIXED THRU ZERO
CC
      ZML2(B,STD,IP) = 0.0
      DET2(B,STD,IP) = SUMXY / SUMXX
CC
```

```
615       100 CONTINUE
616       CC
617         999 RETURN
618             END
```

```
      SUBROUTINE BAGF(STD)
CC
CC    THIS SUBROUTINE CALCULATES BAG FRACTIONS
CC
      COMMON/BAG/ZML2(5,7,3),DET2(5,7,3)
      COMMON/OUT/RED(19,2,7,3,3),ZMLC(5,7,3),DETC(5,7,3)
CC
      INTEGER STD
      REAL BAGF(3)/0.206, 0.521, 0.273/
      REAL ZMLF(2,4),DETF(2,4)
CC
      DO 50 IP=1,2
CC
      ZMLF(IP,1) = 0.0
      DETF(IP,1) = 0.0
CC
      DO 50 IBAG=2,4
CC
      ZMLF(IP,IBAG) = ZML2(IBAG,STD,IP)
      DETF(IP,IBAG) = DET2(IBAG,STD,IP)
CC
      ZMLF(IP,1) = ZMLF(IP,1) + ZML2(IBAG,STD,IP) * BAGF(IBAG-1)
      DETF(IP,1) = DETF(IP,1) + DET2(IBAG,STD,IP) * BAGF(IBAG-1)
CC
   50 CONTINUE
CC
CC
      DO 60 IP=1,2
      DO 60 IBAG=1,4
CC
      ZMLC(IBAG,STD,IP) = ZMLF(IP,IBAG) / ZMLF(IP,1)
      DETC(IBAG,STD,IP) = DETF(IP,IBAG) / ZMLF(IP,1)
CC
   60 CONTINUE
CC
      RETURN
      END
```

```
656           SUBROUTINE NOXEF
657      CC
658      CC...THIS ROUTINE CALCULATES NOX VALUES
659      CC
660      CC
661      CC     MYG = 1 : 1981 MYR (7.0 CO STD)
662      CC     MYG = 2 : 1981 MYR (3.4 CO STD)
663      CC     MYG = 3 : 1982 MYR (7.0 CO STD)
664      CC     MYG = 4 : 1982 MYR (3.4 CO STD)
665      CC     MYG = 5 : 1983 MYR
666      CC     MYG = 6 : 1984 MYR
667      CC     MYG = 7 : 1985-1986 MYRS
668      CC     MYG = 8 : 1987-1989 MYRS
669      CC     MYG = 9 : 1990 & LATER MYRS
670      CC
671      CC     STD = 1 : 1981+ MYR / 3.4 CO STANDARD
672      CC     STD = 2 : 1981  MYR / 7.0 CO STANDARD
673      CC     STD = 3 : 1982  MYR / 7.0 CO STANDARD
674      CC
675      CC     BAG = 1 : COMPOSITE FTP
676      CC     BAG = 2 : COLD START BAG 1
677      CC     BAG = 3 : TRANSIENT  BAG 2
678      CC     BAG = 4 : HOT START  BAG 3
679      CC     BAG = 5 : BAGGED IDLE
680      CC
681      CC     TECH = 1 : OXIDATION/3-WAY CATALYST, CLOSED-LOOP, CARBURATED.
682      CC     TECH = 2 : 3-WAY CATALYST, CLOSED-LOOP, CARBURATED.
683      CC     TECH = 3 : OXIDATION/3-WAY CATALYST, CLOSED-LOOP, FUEL INJECTED.
684      CC     TECH = 4 : 3-WAY CATALYST, CLOSED-LOOP, FUEL INJECTED.
685      CC     TECH = 5 : 3-WAY CATALYST, OPEN-LOOP, ALL
686      CC     TECH = 6 : OXIDATION CATALYST, ALL
687      CC
688            COMMON/BAG/ZML2(5,7,3),DET2(5,7,3)
689            COMMON/FRC/FRAC
690      CC
691            INTEGER STD,AGE,BAG,TECH,MYG,MYR
692            REAL MDIF(20),FRAC(6,9)
693            REAL ZML1(5,12),DET1(5,12)
694            LOGICAL*4 LAB2(5)/' FTP',
695           *                  'BAG1',
696           *                  'BAG2',
697           *                  'BAG3',
698           *                  'BAGI'/
699      CC
700      CC....NOX REGRESSION ZERO-MILE LEVELS : ZML(BAG,TECH,STD)
701      CC
702            REAL ZML(5,6,3) /
703      CC
704      CC  1981+ 3.4 CO STANDARD
705      CC
706           *     0.5328, 1.0096, 0.3870, 0.5170, 0.0,
707           *     0.5328, 1.0096, 0.3870, 0.5170, 0.0,
708           *     0.5328, 1.0096, 0.3870, 0.5170, 0.0,
709           *     0.5328, 1.0096, 0.3870, 0.5170, 0.0,
710           *     0.5626, 0.8423, 0.4506, 0.5628, 0.0,
711           *     0.7592, 1.0717, 0.5935, 0.8380, 0.0,
712      CC
```

```
713     CC  1981 7.0 CO STANDARD
714     CC
715           *     0.6942, 1.0788, 0.5310, 0.7127, 0.0,
716           *     0.5433, 1.1605, 0.3938, 0.3597, 0.0,
717           *     0.6942, 1.0788, 0.5310, 0.7127, 0.0,
718           *     0.5433, 1.1605, 0.3938, 0.3597, 0.0,
719           *     0.4101, 0.7819, 0.2722, 0.3909, 0.0,
720           *     0.6735, 1.0702, 0.4874, 0.7283, 0.0,
721     CC
722     CC  1982 7.0 CO STANDARD
723     CC
724           *     0.6717, 1.0926, 0.5108, 0.6573, 0.0,
725           *     0.5510, 1.0958, 0.3864, 0.4203, 0.0,
726           *     0.6717, 1.0926, 0.5108, 0.6573, 0.0,
727           *     0.5510, 1.0958, 0.3864, 0.4203, 0.0,
728           *     0.6933, 0.8957, 0.6504, 0.6231, 0.0,
729           *     0.6658, 1.0896, 0.4115, 0.8221, 0.0/
730     CC
731     CC....NOX REGRESSION DETERIORATION RATES : DET(BAG,TECH)
732     CC
733           REAL DET(5,6) / 0.09534, 0.09324, 0.08205, 0.12259, 0.0,
734          *                0.09534, 0.09324, 0.08205, 0.12259, 0.0,
735          *                0.09534, 0.09324, 0.08205, 0.12259, 0.0,
736          *                0.09534, 0.09324, 0.08205, 0.12259, 0.0,
737          *                0.07692, 0.06917, 0.07539, 0.08572, 0.0,
738          *                0.01821, 0.00121, 0.02323, 0.02156, 0.0/
739     CC
740     CC....WEIGHT LINEAR REGRESSIONS
741     CC
742           DO 50 BAG=1,4
743           DO 40 MYG=1,9
744     C
745           ZML1(BAG,MYG) = 0.0
746           DET1(BAG,MYG) = 0.0
747     C
748           STD = 1
749           IF(MYG.EQ.2) STD=2
750           IF(MYG.EQ.4) STD=3
751     C
752           DO 40 TECH=1,6
753     C
754           ZML1(BAG,MYG) = ZML1(BAG,MYG)+ZML(BAG,TECH,STD)*FRAC(TECH,MYG)/100.
755           DET1(BAG,MYG) = DET1(BAG,MYG)+DET(BAG,TECH)    *FRAC(TECH,MYG)/100.
756     C
757        40 CONTINUE
758     C
759           ZML1(BAG,10) = ZML1(BAG,1) + ZML1(BAG,2)
760           DET1(BAG,10) = DET1(BAG,1) + DET1(BAG,2)
761           ZML1(BAG,11) = ZML1(BAG,3) + ZML1(BAG,4)
762           DET1(BAG,11) = DET1(BAG,3) + DET1(BAG,4)
763     C
764        50 CONTINUE
765     CC
766           DO 60 BAG=1,4
767     CC
768           ZML2(BAG,1,3) = ZML1(BAG,10)
769           ZML2(BAG,2,3) = ZML1(BAG,11)
```

```
770             ZML2(BAG,3,3) = ZML1(BAG,5)
771             ZML2(BAG,4,3) = ZML1(BAG,6)
772             ZML2(BAG,5,3) = ZML1(BAG,7)
773             ZML2(BAG,6,3) = ZML1(BAG,8)
774             ZML2(BAG,7,3) = ZML1(BAG,9)
775     CC
776             DET2(BAG,1,3) = DET1(BAG,10)
777             DET2(BAG,2,3) = DET1(BAG,11)
778             DET2(BAG,3,3) = DET1(BAG,5)
779             DET2(BAG,4,3) = DET1(BAG,6)
780             DET2(BAG,5,3) = DET1(BAG,7)
781             DET2(BAG,6,3) = DET1(BAG,8)
782             DET2(BAG,7,3) = DET1(BAG,9)
783     CC
784          60 CONTINUE
785     CC
786             CALL NOXBF
787     CC
788     C
789             RETURN
790             END
```

```
      SUBROUTINE NOXBF
CC
CC    THIS SUBROUTINE CALCULATES BAG FRACTIONS
CC
      COMMON/BAG/ZML2(5,7,3),DET2(5,7,3)
      COMMON/OUT/RED(19,2,7,3,3),ZMLC(5,7,3),DETC(5,7,3)
CC
      INTEGER STD
      REAL BAGF(3)/0.206, 0.521, 0.273/
      REAL ZMLF(4),DETF(4)
CC
      DO 90 STD=1,7
CC
      ZMLF(1) = 0.0
      DETF(1) = 0.0
CC
      DO 50 IBAG=2,4
CC
      ZMLF(IBAG) = ZML2(IBAG,STD,3)
      DETF(IBAG) = DET2(IBAG,STD,3)
CC
      ZMLF(1) = ZMLF(1) + ZML2(IBAG,STD,3) * BAGF(IBAG-1)

      DETF(1) = DETF(1) + DET2(IBAG,STD,3) * BAGF(IBAG-1)
CC
   50 CONTINUE
CC
CC
      DO 60 IBAG=1,4
CC
      ZMLC(IBAG,STD,3) = ZMLF(IBAG) / ZMLF(1)
      DETC(IBAG,STD,3) = DETF(IBAG) / ZMLF(1)
CC
   60 CONTINUE
CC
   90 CONTINUE
CC
      RETURN
      END
```

```
      SUBROUTINE OUTPUT
CC
      COMMON/OUT/RED(19,2,7,3,3),ZMLC(5,7,3),DETC(5,7,3)
      COMMON/BAG/ZML2(5,7,3),DET2(5,7,3)
CC
      INTEGER ITEST,ICUTS,STD,IP,IBY,IBAG
      LOGICAL*4 LAB1(3)/'  HC',' CO',' NOX'/
      LOGICAL*4 LAB2(5)/'FTP ',
     *                  'BAG1',
     *                  'BAG2',
     *                  'BAG3',
     *                  'BAGI'/
      LOGICAL*4 LAB3(7)/'81  ',
     *                  '82  ',
     *                  '83  ',
     *                  '84  ',
     *                  '8586',
     *                  '8789',
     *                  '90+ '/
CC
      N1 = 1
      N3 = 3
CC
CC....WRITE OUT TABLE HEADINGS
CC
      WRITE(7,100) N3
      DO 10 ITEST=1,3
      DO 10 ICUTS=1,3
      DO 10 STD=1,7
      DO 10 IP=1,2
      WRITE(7,200) (RED(IBY,IP,STD,ICUTS,ITEST),IBY=1,19)
   10 CONTINUE
CC
      WRITE(8,100) N1
      DO 20 IP=1,3
      WRITE(8,500)
      DO 20 STD=1,7
      DO 20 IBAG=1,1
      WRITE(8,300) LAB3(STD),LAB2(IBAG),LAB1(IP),
     *  ZML2(IBAG,STD,IP),DET2(IBAG,STD,IP),
     *  ZML2(IBAG,STD,IP),DET2(IBAG,STD,IP)
   20 CONTINUE
CC
      WRITE(9,100) N1
      DO 30 IP=1,3
      WRITE(9,500)
      DO 30 STD=1,7
      WRITE(9,400) LAB3(STD),LAB1(IP),
     *(ZMLC(IBAG,STD,IP),DETC(IBAG,STD,IP),IBAG=2,4),
     * ZMLC(1,STD,IP),DETC(1,STD,IP)
   30 CONTINUE
CC
  100 FORMAT(I1,/,' **',/,
     *' ** 1981 & LATER LOW-ALTITUDE ',
     */,' **')
  200 FORMAT(19F4.3)
  300 FORMAT(' 19',A4,' EF EQUATION : ',2A4,'=',
```

```
886          * F6.2,' + ',F6.2,' * MILES/10000',3X,2F12.5)
887        400 FORMAT(' 19',2A4,8F7.3)
888        500 FORMAT('-')
889      CC
890           RETURN
891           END
```

```
892             BLOCK DATA
893       CC
894       CC
895       CC...BLOCK DATA WITH TECH IV INPUT (UPDATED 4/14/84)
896       CC
897             COMMON/INPUT/SHO,SSO,GH,GS,ESO,DS,ENOO,DN,EHO,DH
898             COMMON/FRC/FRAC
899             COMMON/ODOM/RATE,MILE,SRATE,MDIF
900             COMMON/MACC/JMILE
901             COMMON/IMS/INSP,FINSP,STD,IDR,IY,T,B
902             COMMON/WRG/WGT
903       CC
904       CC...MOBILE3
905       CC
906             REAL SSO(2,5,6) /
907       CC
908       CC    SIZE OF THE SUPERS AT ZERO (INTERCEPT)
909       CC
910            * 0.0000,0.0000,  0.0000,0.0000, 0.0000,0.0000,
911            * 0.0000,0.0000,  0.0000,0.0000,
912       CC
913            * 0.0000,0.0000,  0.0000,0.0000, 0.0000,0.0000,
914            * 0.0000,0.0000,  0.0000,0.0000,
915       CC
916            * 0.0000,0.0000,  0.0000,0.0000, 0.0000,0.0000,
917            * 0.0000,0.0000,  0.0000,0.0000,
918       CC
919            * 0.0000,0.0000,  0.0000,0.0000, 0.0000,0.0000,
920            * 0.0000,0.0000,  0.0000,0.0000,
921       CC
922            * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
923            * 0.000 ,0.000 ,  0.000 ,0.000,
924       CC
925            * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
926            * 0.000 ,0.000 ,  0.000 ,0.000 /
927       CC
928             REAL GS(2,5,6) /
929       CC
930       CC    GROWTH OF NUMBER (SIZE) OF SUPERS (PER 10K MILES)
931       CC
932            * .002563,.002563,  .002563,.002563, .002563,.002563,
933            * .002563,.002563,  .002563,.002563,
934       CC
935            * .002563,.002563,  .002563,.002563, .002563,.002563,
936            * .002563,.002563,  .002563,.002563,
937       CC
938            * .001281,.001281,  .001281,.001281, .001281,.001281,
939            * .001281,.001281,  .001281,.001281,
940       CC
941            * .001281,.001281,  .001281,.001281, .001281,.001281,
942            * .001281,.001281,  .001281,.001281,
943       CC
944            * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
945            * 0.000 ,0.000 ,  0.000 ,0.000,
946       CC
947            * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
948            * 0.000 ,0.000 ,  0.000 ,0.000 /
```

```
      CC
            REAL SHO(2,5,6) /
      CC
      CC    SIZE OF THE HIGHS AT ZERO (INTERCEPT)
      CC
           * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
           * 0.000 ,0.000 ,  0.000 ,0.000,
      CC
           * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
           * 0.000 ,0.000 ,  0.000 ,0.000,
      CC
           * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
           * 0.000 ,0.000 ,  0.000 ,0.000,
      CC
           * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
           * 0.000 ,0.000 ,  0.000 ,0.000,
      CC
           * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
           * 0.000 ,0.000 ,  0.000 ,0.000,
      CC
           * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
           * 0.000 ,0.000 ,  0.000 ,0.000 /
      CC
            REAL GH(2,5,6) /
      CC
      CC    GROWTH OF NUMBER (SIZE) OF HIGHS (PER 10K MILES)
      CC
           * 0.0250,0.0250,  0.0250,0.0250, 0.0250,0.0250,
           * 0.0250,0.0250,  0.0250,0.0250,
      CC
           * 0.0250,0.0250,  0.0250,0.0250, 0.0250,0.0250,
           * 0.0250,0.0250,  0.0250,0.0250,
      CC
           * 0.0193,0.0193,  0.0193,0.0193, 0.0193,0.0193,
           * 0.0193,0.0193,  0.0193,0.0193,
      CC
           * 0.0193,0.0193,  0.0193,0.0193, 0.0193,0.0193,
           * 0.0193,0.0193,  0.0193,0.0193,
      CC
           * 0.0401,0.0401,  0.0401,0.0401, 0.0401,0.0401,
           * 0.0401,0.0401,  0.0401,0.0401,
      CC
           * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
           * 0.000 ,0.000 ,  0.000 ,0.000 /
      CC
            REAL ESO(2,5,6)/
      CC
      CC    EMISSIONS OF THE SUPERS
      CC
           * 14.132, 193.23,  30.937, 181.02,  10.867, 210.72,
           *  7.508, 169.22,   1.100,  16.007,
      CC
           * 14.132, 193.23,  30.937, 181.02,  10.867, 210.72,
           *  7.508, 169.22,   1.100,  16.007,
      CC
           * 10.560, 191.72,   8.090, 170.45,  12.645, 215.45,
           *  8.460, 162.55,   0.000, 000.00,
```

```
1006     CC
1007          * 10.560, 191.72,   8.090, 170.45,  12.645, 215.45,
1008          *  8.460, 162.55,   0.000, 000.00,
1009     CC
1010          * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
1011          * 0.000 ,0.000 ,  0.000 ,0.000,
1012     CC
1013          * 0.000 ,0.000 ,  0.000 ,0.000,  0.000 ,0.000,
1014          * 0.000 ,0.000 ,  0.000 ,0.000 /
1015     CC
1016          REAL DS(2,5,6) /
1017     CC
1018     CC  DETERIORATION OF SUPERS (EMISSIONS)
1019     CC
1020          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1021          * 0.000, 0.000,  0.000, 0.000,
1022     CC
1023          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1024          * 0.000, 0.000,  0.000, 0.000,
1025     CC
1026          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1027          * 0.000, 0.000,  0.000, 0.000,
1028     CC
1029          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1030          * 0.000, 0.000,  0.000, 0.000,
1031     CC
1032          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1033          * 0.000, 0.000,  0.000, 0.000,
1034     CC
1035          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1036          * 0.000, 0.000,  0.000, 0.000 /
1037     CC
1038          REAL EHO(2,5,6)/
1039     CC
1040     CC  FOLLOWING IS THE EMISSIONS OF THE HIGHS AT ZERO (INTERCEPT)
1041     CC
1042          * 2.2997, 39.137,   4.6408, 61.181,  1.7954, 35.503,
1043          * 1.4857, 29.354,   0.0000,  0.000,
1044     CC

1045          * 2.2997, 39.137,   4.6408, 61.181,  1.7954, 35.503,
1046          * 1.4857, 29.354,   0.0000,  0.000,
1047     CC
1048          * 2.3556, 38.212,   4.2419, 53.030,  1.9737, 36.496,
1049          * 1.6574, 30.292,   0.0000,  0.000,
1050     CC
1051          * 2.3556, 38.212,   4.2419, 53.030,  1.9737, 36.496,
1052          * 1.6574, 30.292,   0.0000,  0.000,
1053     CC
1054          * 2.2511, 34.607,   3.6050, 50.422,  1.7850, 30.528,
1055          * 2.1094, 30.361,   0.0000,  0.000,
1056     CC
1057          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1058          * 0.000, 0.000,  0.000, 0.000 /
1059     CC
1060          REAL DH(2,5,6) /
1061     CC
1062     CC  FOLLOWING IS THE DETERIORATION OF THE EMISSIONS FOR HIGHS
```

```
1063     CC
1064          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1065          * 0.000, 0.000,  0.000, 0.000,
1066     CC
1067          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1068          * 0.000, 0.000,  0.000, 0.000,
1069     CC
1070          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1071          * 0.000, 0.000,  0.000, 0.000,
1072     CC
1073          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1074          * 0.000, 0.000,  0.000, 0.000,
1075     CC
1076          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1077          * 0.000, 0.000,  0.000, 0.000,
1078     CC
1079          * 0.000, 0.000,  0.000, 0.000,  0.000, 0.000,
1080          * 0.000, 0.000,  0.000, 0.000 /
1081     CC
1082     CC  FOLLOWING IS EMISSIONS OF THE NORMALS AT ZERO (INTERCEPT)
1083     CC
1084           REAL EN00(2,5,6,3)/
1085     CC
1086     CC  THIS IS THE DATA FOR 3.4 GM/MI CO STANDARD VEHICLES
1087     CC
1088          *0.2260,1.948,0.5271,5.550,0.1117,0.612,0.2127,1.748,0.0,0.0,
1089          *0.2260,1.948,0.5271,5.550,0.1117,0.612,0.2127,1.748,0.0,0.0,
1090          *0.2260,1.948,0.5271,5.550,0.1117,0.612,0.2127,1.748,0.0,0.0,
1091          *0.2260,1.948,0.5271,5.550,0.1117,0.612,0.2127,1.748,0.0,0.0,
1092          *0.3229,2.823,0.6930,7.665,0.1803,0.542,0.3136,3.199,0.0,0.0,
1093          *0.2768,2.507,0.7663,6.867,0.1195,1.001,0.2087,2.070,0.0,0.0,
1094     CC
1095     CC  THIS IS THE DATA FOR 1981 7.0 GM/MI CO STANDARD VEHICLES
1096     CC
1097          *0.3056,3.201,0.8780,10.927,0.1056,0.535,0.2521,2.405,0.0,0.0,
1098          *0.3048,4.277,0.7798,10.925,0.1370,2.133,0.2621,3.302,0.0,0.0,
1099          *0.3056,3.201,0.8780,10.927,0.1056,0.535,0.2521,2.405,0.0,0.0,
1100          *0.3048,4.277,0.7798,10.925,0.1370,2.133,0.2621,3.302,0.0,0.0,
1101          *0.3700,5.775,0.5573, 9.568,0.2705,3.535,0.4175,6.827,0.0,0.0,
1102          *0.2220,3.398,0.5366,11.870,0.1178,0.722,0.1786,2.048,0.0,0.0,
1103     CC
1104     CC  THIS IS THE DATA FOR 1982 7.0 GM/MI CO STANDARD VEHICLES
1105     CC
1106          *0.2513,2.994,0.7141,10.092,0.0951,0.475,0.1959,2.392.0.0,0.0,
1107          *0.2041,2.824,0.6145, 6.710,0.0771,1.654,0.1333,2.091,0.0,0.0,
1108          *0.2513,2.994,0.7141,10.092,0.0951,0.475,0.1959,2.392,0.0,0.0,
1109          *0.2041,2.824,0.6145, 6.710,0.0771,1.654,0.1333,2.091,0.0,0.0,
1110          *0.3435,4.395,0.5744,10.212,0.2319,1.821,0.3795,4.836,0.0,0.0,
1111          *0.1801,2.787,0.5011, 9.454,0.0967,1.125,0.1034,0.958,0.0,0.0/
1112     CC
1113           REAL DN(2,5,6) /
1114     CC
1115     CC  FOLLOWING IS THE DETERIORATION OF THE EMISSIONS OF THE NORMALS
1116     CC
1117     CC
1118          * 0.04998, 0.6459,  0.11907, 1.6554,  0.03304, 0.3777,
1119          * 0.03067, 0.3988,  0.00000, 0.0000,
```

```
1120     CC
1121          * 0.04998, 0.6459,  0.11907, 1.6554,  0.03304, 0.3777,
1122          * 0.03067, 0.3988,  0.00000, 0.0000,
1123     CC
1124          * 0.04998, 0.6459,  0.11907, 1.6554,  0.03304, 0.3777,
1125          * 0.03067, 0.3988,  0.00000, 0.0000,
1126     CC
1127          * 0.04998, 0.6459,  0.11907, 1.6554,  0.03304, 0.3777,
1128          * 0.03067, 0.3988,  0.00000, 0.0000,
1129     CC
1130          * 0.04507, 0.1713,  0.08728, 0.7530,  0.02780, 0.0000,
1131          * 0.04670, 0.2001,  0.00000, 0.0000,
1132     CC
1133          * 0.02681, 0.4638,  0.09240, 1.4863,  0.00911, 0.2053,
1134          * 0.01129, 0.1824,  0.00000, 0.0000/
1135     CC
1136     CC....TECHNOLOGY FRACTIONS : FRAC(TECH,MYG)
1137     CC
1138           REAL FRAC(6,9)/
1139          * 23.1,  4.5,  1.0,  2.3,  7.6, 10.3,
1140          * 15.1, 18.1,  1.9,  4.2,  7.5,  4.4,
1141          *  3.6,  3.8,  1.4,  5.6,  2.3, 10.1,
1142          * 32.7, 12.7,  2.3,  9.0, 12.8,  3.7,
1143          * 45.3,  2.1, 27.6,  0.0, 13.1, 11.9,
1144          * 43.4, 11.9, 40.0,  0.0,  4.7,  0.0,
1145          * 23.5, 11.1, 61.0,  0.0,  4.4,  0.0,
1146          * 11.2,  8.5, 79.5,  0.0,  0.8,  0.0,
1147          *  4.0,  6.2, 88.8,  0.0,  1.0,  0.0 /
1148     CC
1149     CC  EXCESS EMISSION IDENTIFICATION RATE FOR SUPERS
1150     CC              SRATE(P,CARB/FI)
1151     CC
1152           REAL SRATE(2,2)/ 0.560, 0.826,
1153          *                 1.000, 1.000/
1154     CC
1155     CC  EXCESS EMISSION IDENTIFICATION RATES FOR HIGHS
1156     CC              RATE(IDR,P)
1157     CC
1158           REAL RATE(9,2)/
1159          *  0.515, 0.379, 0.224,
1160          *  0.643, 0.504, 0.333,
1161          *  0.743, 0.572, 0.397,
1162     CC
1163          *  0.547, 0.450, 0.283,
1164          *  0.732, 0.626, 0.424,
1165          *  0.837, 0.712, 0.486/
1166     CC
1167           LOGICAL FINSP(3)/.TRUE.,.FALSE.,.TRUE./
1168     CC
1169           REAL WGT(20) / 0.037, 0.140, 0.125, 0.111, 0.097,
1170          *               0.086, 0.075, 0.064, 0.056, 0.048,
1171          *               0.040, 0.034, 0.028, 0.022, 0.016,
1172          *               0.011, 0.007, 0.003, 0.000, 0.000/
1173     CC
1174           REAL MILE(20)/ 1.2818, 2.4920, 3.6347, 4.7136, 5.7323,
1175          *               6.6942, 7.6024, 8.4599, 9.2695,10.0340,
1176          *              10.7558,11.4373,12.0808,12.6884,13.2621,
```

```
1177          *                  13.8037,14.3151,14.7979,15.2538,15.6843/
1178     CC
1179           REAL JMILE(19)/          0.9591, 2.1873, 3.3470, 4.4420,
1180          *                   5.4758, 6.4520, 7.3738, 8.2440, 9.0657,
1181          *                   9.8415,10.5741,11.2657,11.9188,12.5354,
1182          *                  13.1176,13.6673,14.1863,14.6764,15.1390/
1183     CC
1184           END
```